Eye Chart Experiment results

Updated: August 21, 2018

Contents

1 To Do (udpated August 8, 2018)

- Kolmogorov Smirnov tests to compare average distributions (combine distributions across subjects)
- redo drift speed and curvature analyses with same control for preceding microsaccade size and for ms < 30 only (done for diffusion constants)
- replace MS rate figure in manuscript?
- compute drift power for each individual (BM with individual diffusion constant) - measure change in power at 30cpd

2 Overview of Resources

Raw EyeRIS files are stored in `//casfsb/APLAB/JanisData/APLab/EyeChartE_Stuff` in folders labelled by subject initials. Preprocessed data are also in matlab files in these folders.

Analysis results are in many dated folders in `//casfsb/APLAB/JanisData/APLab/EyeChartE_Stuff/Results`, with one matlab file for each subject. Plots for individual subjects are stored in the corresponding Figures folder with combined and across subject analyses and figures stored in the corresponding Combined folder.

All code is available on `https://gitlab.com/jintoy/EyeChartExperiment` - including Matlab analysis code and the experiment code. Main parts of analysis code:

- EISFileReading folder: contains matlab code to load in eis and preprocess data
- runOneSubject: function entry point for main analyses. Data analysis for a single subject. Uses many subfunctions including but not limited to:
  - analyzeEM - analyzes eye movement data
  - gatherBehavioralData - analyzes response data
  - analyzePerformance - attempt to correlate behavior with performance
  - fitPsychCurves - fits psychometric functions
- runMultipleSubjects: script calls runOneSubject for each individual
- postProcessBatch: script puts all subjects data together
- combinedResults: function that analyzes combined data (across subject comparisons)
- Plotting folder: folder with most plotting functions

3 Experiment Description

4 Conditions:

- normal viewing (6 tumbling-Es, 20/20), contrast follows pest
- stabilized viewing (6 tumbling-Es, 20/20), contrast follows pest
- stabilized viewing, size follows method of constant stimuli
- fixation on center of line (6 tumbling-Es, 20/20), contrast fixed

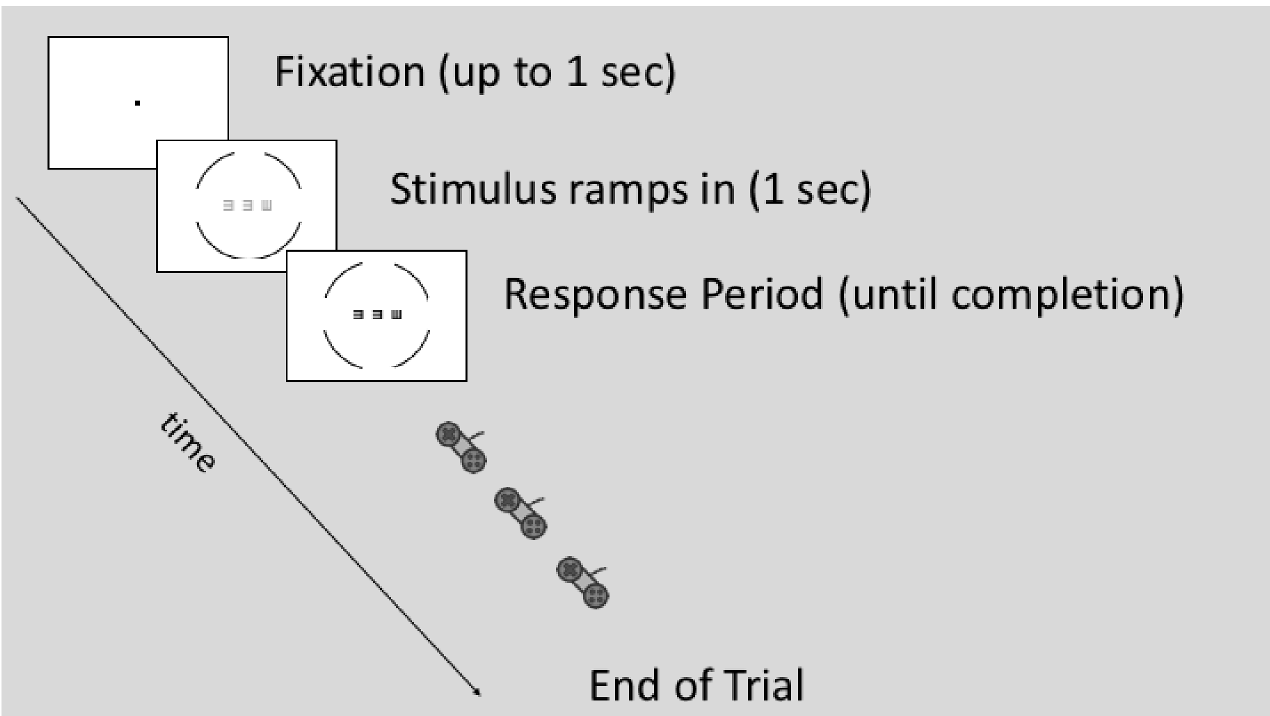


Figure 1: Trial Flow

4 Data Collection

- 7 subjects: 5 females, 2 males
- invalid trial criteria:
  - blink or no track > 300ms continuously during stimulus plateau
  - saccades > 2-degrees during stimulus plateau
- events that start within 300ms of a blink/NT are invalidated

The following table is generated by the script
`https://gitlab.com/jintoy/EyeChartExperiment/blob/master/Analysis/printNumberOfTrials.m`

	Normal			Stabilized-Contrast			Stabilized-Size			Control		
Subject	Total	Valid	Near	Total	Valid	Near	Total	Valid	Near	Total	Valid	Near
AB	146	142	103	159	102	13	118	109	30	0	0	NaN
AO	110	109	63	100	96	0	120	119	31	125	41	41
CH	131	112	101	109	78	3	232	195	55	0	0	NaN
CS	144	110	89	69	41	3	169	126	37	0	0	NaN
ML	154	105	84	242	95	12	143	101	21	0	0	NaN
NT	150	137	85	177	109	14	240	212	94	288	233	0
SB	196	131	55	115	98	0	183	148	34	0	0	NaN

Table 1: Number of trials for each subject in each condition. Total, valid (defined above), and near-threshold trials listed for each condition.

5 Eye Movement Characteristics

5.1 Saccades - All Subjects

Summary Statistics:

	Snellen	Fixation	p (sign rank)
Saccade Rate	1.16±0.23	2.46±0.77	0.0156
Saccade Amps	13.31±5.8	21.78±12.54	0.0156

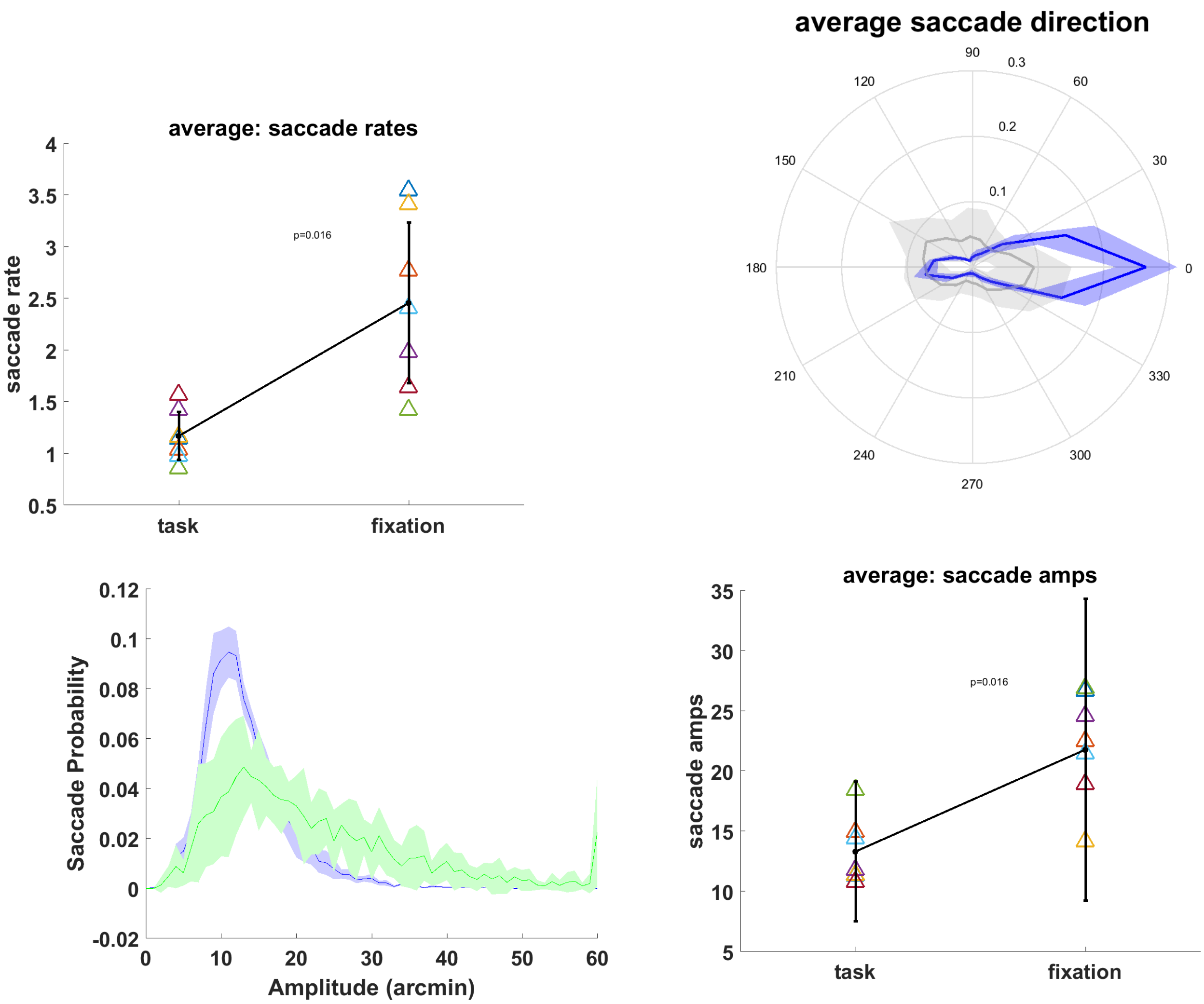


Figure 2: Microsaccade characteristics.

5.2 Saccades - Individuals

	Saccade Amps			Saccade Direction
Subject	Snellen	Fixation	p (Kolm-Smir)	p (Kuiper)
1	11.36±0.11	26.69±18.46	$< 10^{-5}$	0.001
2	14.95±0.20	22.52±10.98	$< 10^{-5}$	0.001
3	11.38±0.10	14.17±5.80	$< 10^{-5}$	0.001
4	11.80±0.13	24.59±12.70	$< 10^{-5}$	0.001
5	18.46±0.21	26.89±12.98	$< 10^{-5}$	0.001
6	14.41±0.14	21.47±16.11	$< 10^{-5}$	0.001
7	10.80±0.13	18.92±13.74	$< 10^{-5}$	0.001

Table 2: Individual statistical tests to compare saccade distributions. Median amplitudes within the individuals can also be compared with a Mann-Whitney U-test ($p < 10^{-9}$ individual_ms_stats.m)

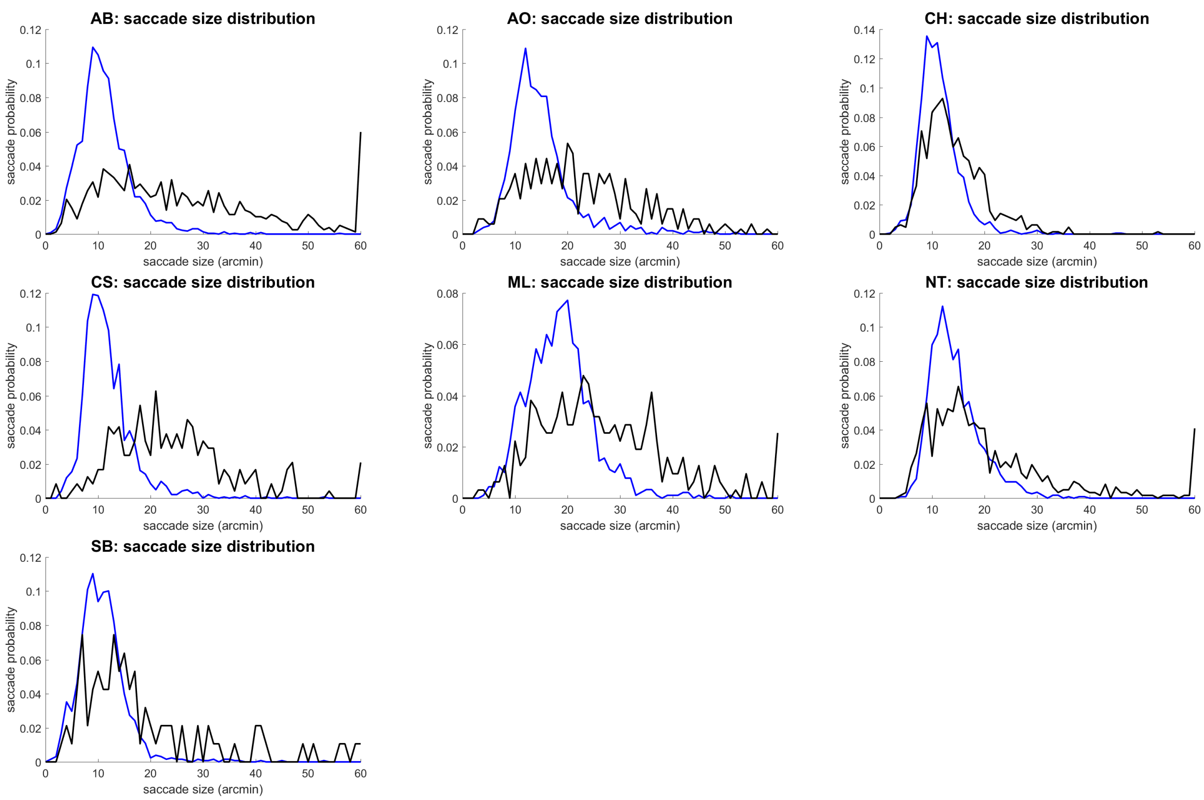


Figure 3: Saccade size distribution for individual subjects for Snellen (blue) and fixation (black). KS test showed significant differences between distributions for all subjects (see Table 2).

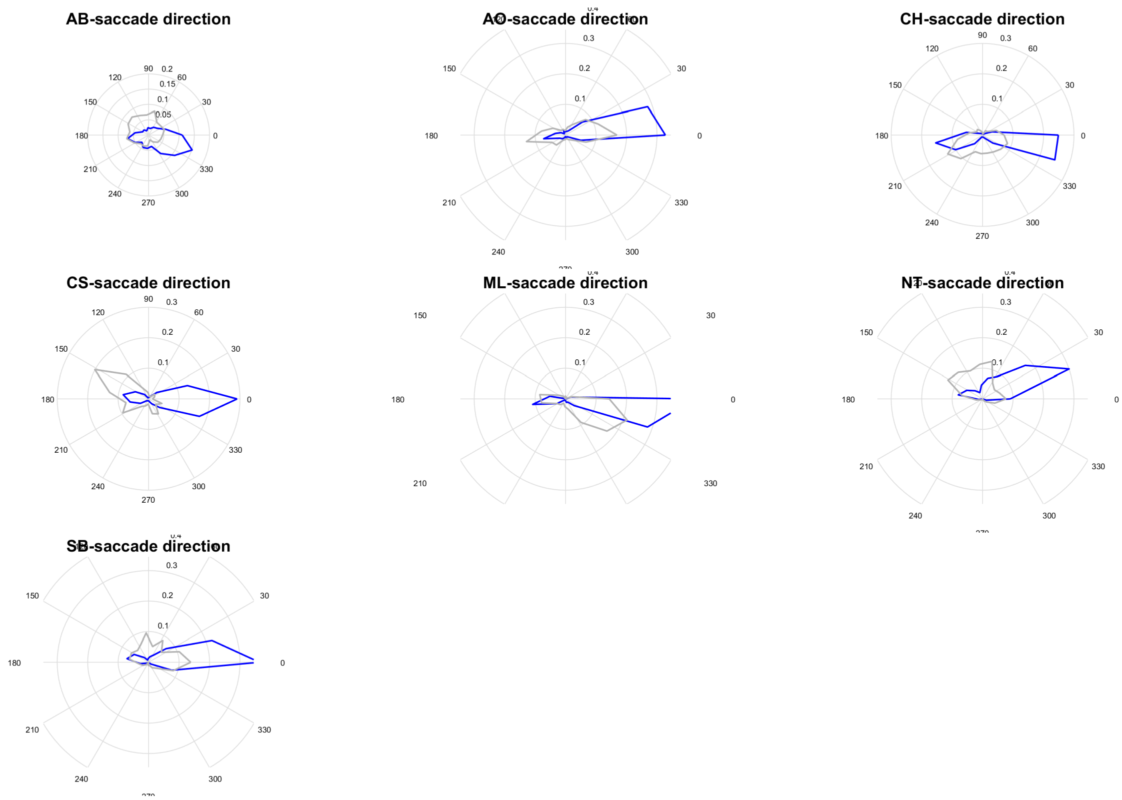


Figure 4: Saccade direction distribution for individual subjects for Snellen (blue) and fixation (black). Kuiper test showed significant differences between distributions for all subjects (see Table 2).

5.3 Saccade Landing Positions - Monte Carlo simulations (Version 1)

Here I followed the type of analysis done in the reading study (Bowers & Poletti, 2017) to measure the effectiveness of microsaccades in moving gaze towards optotypes. In the 'Substituted' simulation (n=2000), saccades in the snellen test were randomly replaced by a saccade produced during fixation (same starting point as saccade). In the Random simulation (n=2000), fixational saccades were randomly placed on the stimulus (starting position within the limits of the optotypes and gaps between). Then, for each optotype in the trial, the minimum distance from the optotype to the nearest saccade landing position is recorded (see MonteCarloSaccades.m). Thus, we only consider the 'best' saccades.

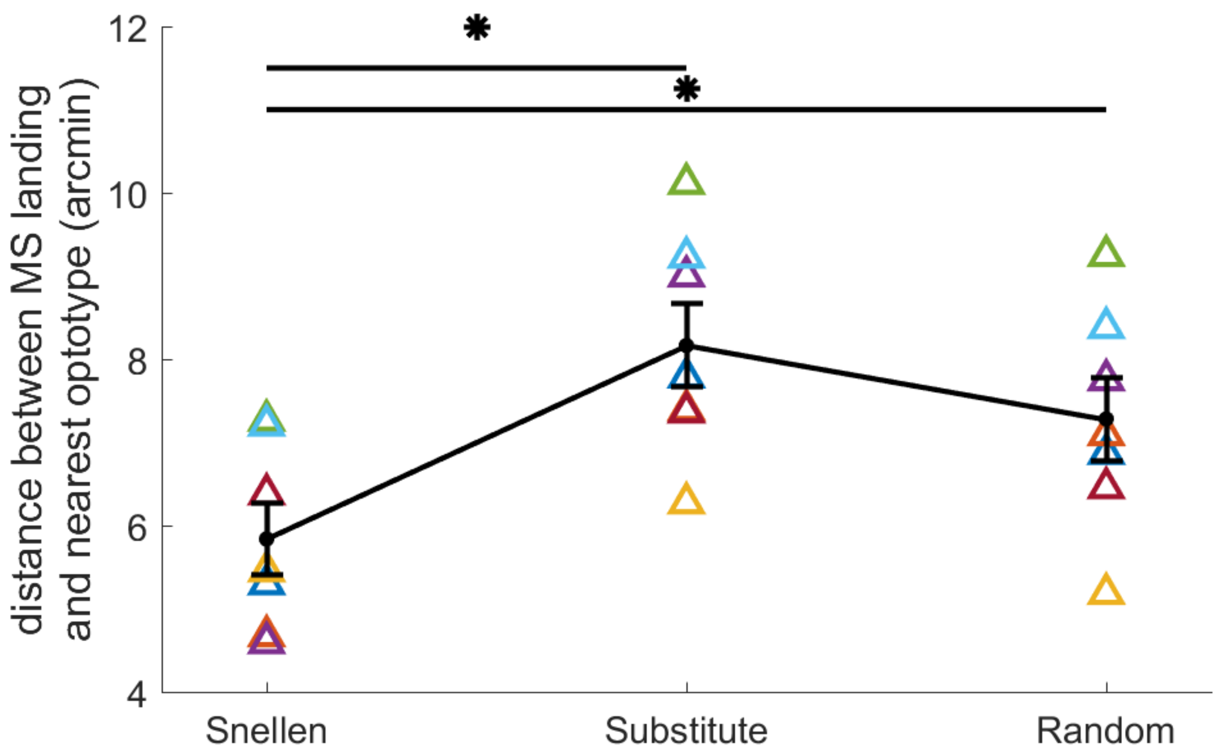
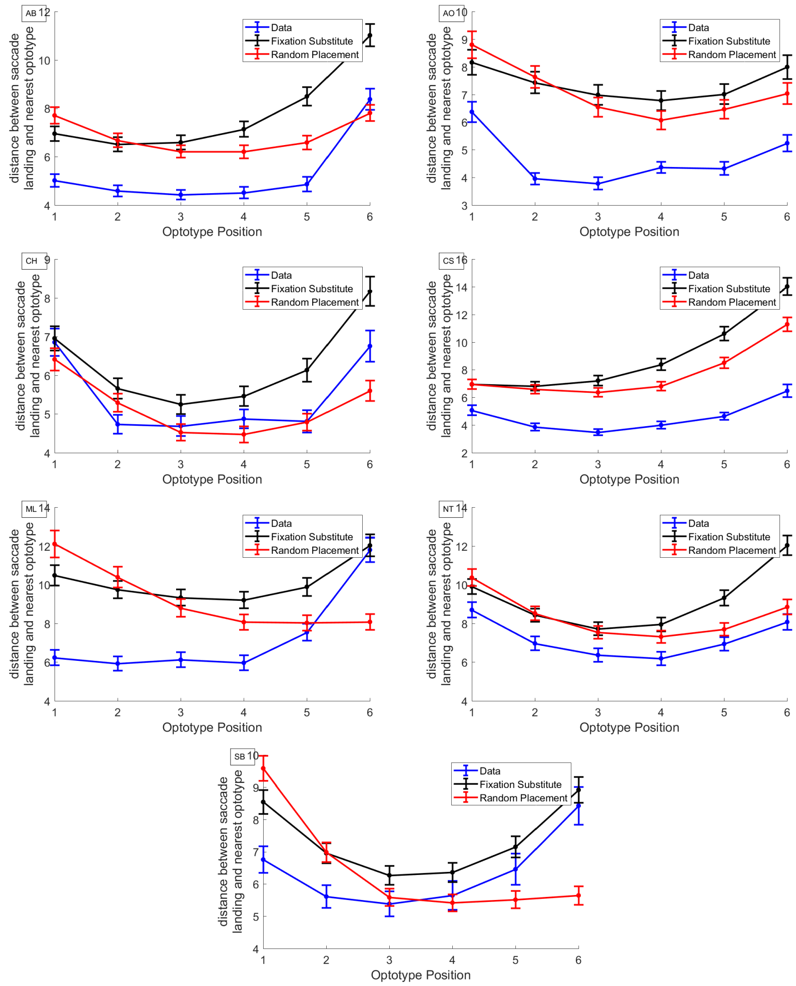


Figure 5: Average distances between optotypes and the **nearest** saccade landing position. ($p = 0.0156$ and $p = 0.0469$, wilcoxon sign rank test for Snellen vs Substitute and Snellen vs random respectively)

	Snellen							Substitute							Random						
Subject	1	2	3	4	5	6	avg	1	2	3	4	5	6	avg	1	2	3	4	5	6	avg
AB	5.02	4.59	4.43	4.52	4.87	8.37	5.30	6.95	6.52	6.59	7.14	8.49	11.02	7.78	7.70	6.67	6.22	6.21	6.59	7.81	6.87
AO	6.37	3.96	3.78	4.37	4.33	5.24	4.67	8.16	7.43	6.99	6.78	7.01	7.99	7.39	8.80	7.63	6.54	6.07	6.47	7.04	7.09
CH	6.85	4.73	4.69	4.88	4.81	6.75	5.45	6.95	5.66	5.25	5.46	6.13	8.17	6.27	6.41	5.29	4.53	4.47	4.79	5.60	5.18
CS	5.07	3.86	3.48	4.00	4.65	6.48	4.59	6.94	6.82	7.22	8.38	10.61	14.02	9.00	6.96	6.59	6.36	6.80	8.51	11.29	7.75
ML	6.24	5.93	6.12	5.97	7.54	11.80	7.27	10.48	9.74	9.33	9.20	9.89	12.03	10.11	12.10	10.39	8.80	8.07	8.03	8.08	9.24
NT	8.70	6.97	6.37	6.19	6.94	8.07	7.21	9.91	8.42	7.73	7.95	9.32	12.03	9.23	10.36	8.52	7.54	7.31	7.69	8.85	8.38
SB	6.75	5.61	5.38	5.64	6.46	8.42	6.38	8.54	6.95	6.27	6.36	7.15	8.91	7.36	9.58	6.98	5.58	5.42	5.51	5.64	6.45
average	6.43±0.47	5.09±0.43	4.89±0.42	5.08±0.32	5.66±0.49	7.88±0.79	5.84±0.42	8.28±0.55	7.36±0.51	7.05±0.48	7.33±0.48	8.37±0.63	10.60±0.87	8.16±0.50	8.85±0.76	7.44±0.62	6.51±0.52	6.34±0.45	6.80±0.51	7.76±0.75	7.28±0.50


AB
AO
CH
CS
ML
NT
SB
Data
Fixation Substitute
Random Placement
distance between saccade landing and nearest optotype
Optotype Position

5.4 Saccade Landing Positions - superimpose fixation on stimulus

sandbox.m - Redid this type of analysis with MonteCarlo simulations

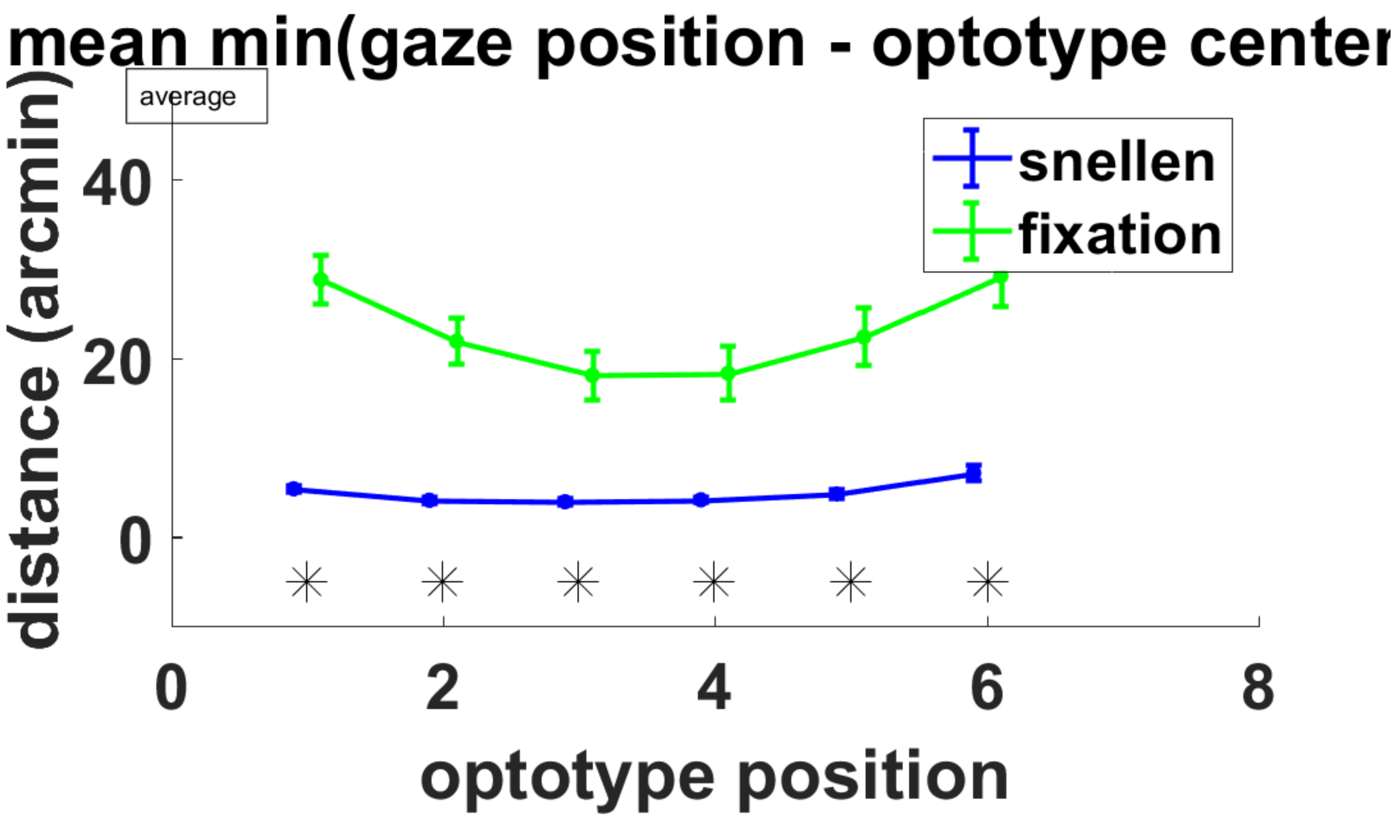


Figure 6: Average distance between microsaccade landing and nearest optotype (using first 50ms after landing). Saccades during Snellen brought gaze closer to each optotype on average than saccades during fixation (measured as though they were superimposed on the snellen stimulus).

	AB	AO	CH	CS	ML	NT	SB	avg
Snellen	4.06	3.80	4.46	3.75	6.49	5.75	5.45	4.82
Fixation	19.45	15.08	21.70	32.80	21.36	19.48	31.69	23.08

Table 3: Average distance (arcmin) between microsaccade landing and nearest optotype in each task (fixation microsaccades superimposed on snellen stimulus) were significantly different (sign rank, $p = 0.0156$)

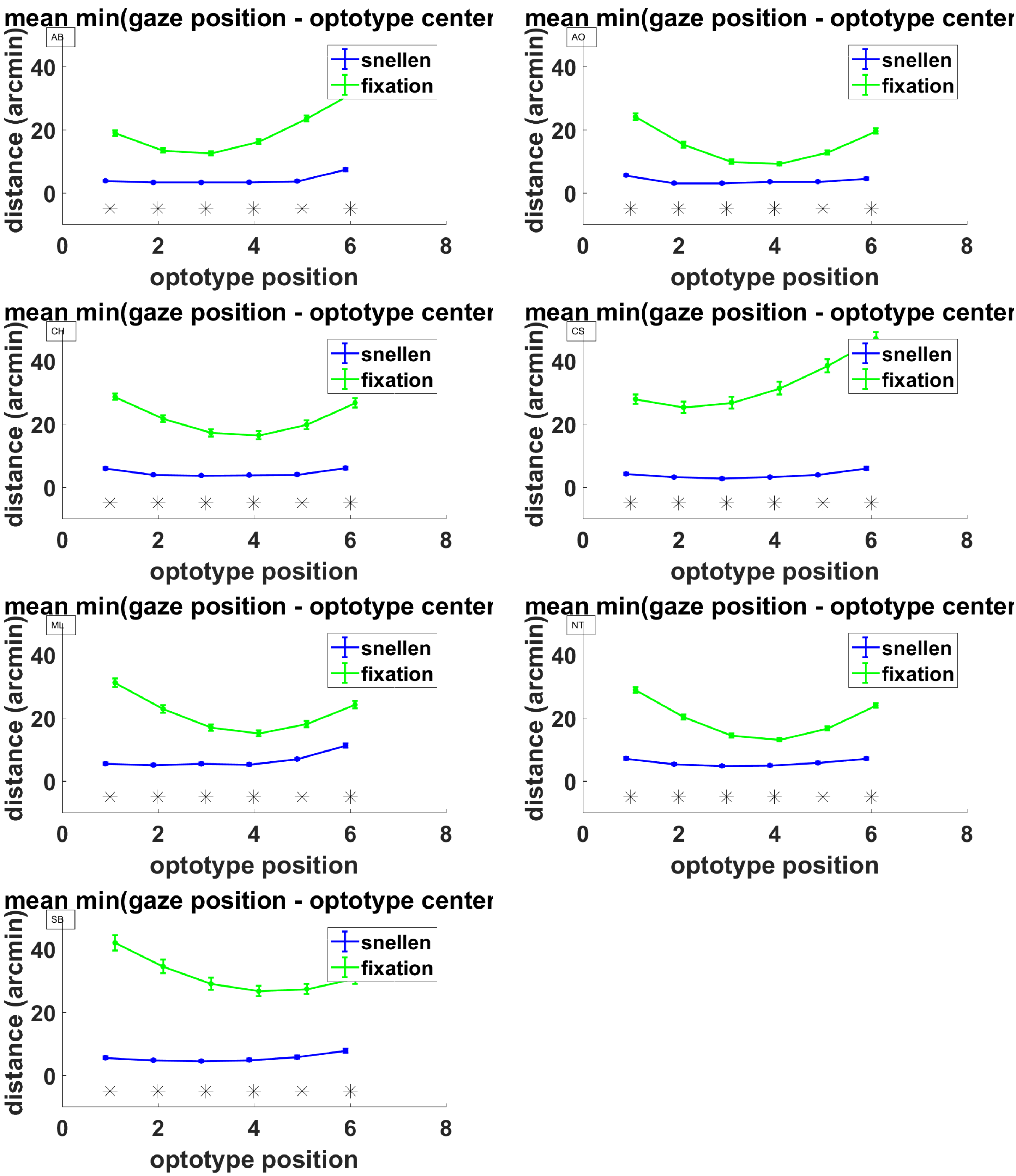


Figure 7: Same as above for each individual subject.

5.5 Saccades - Main Sequences

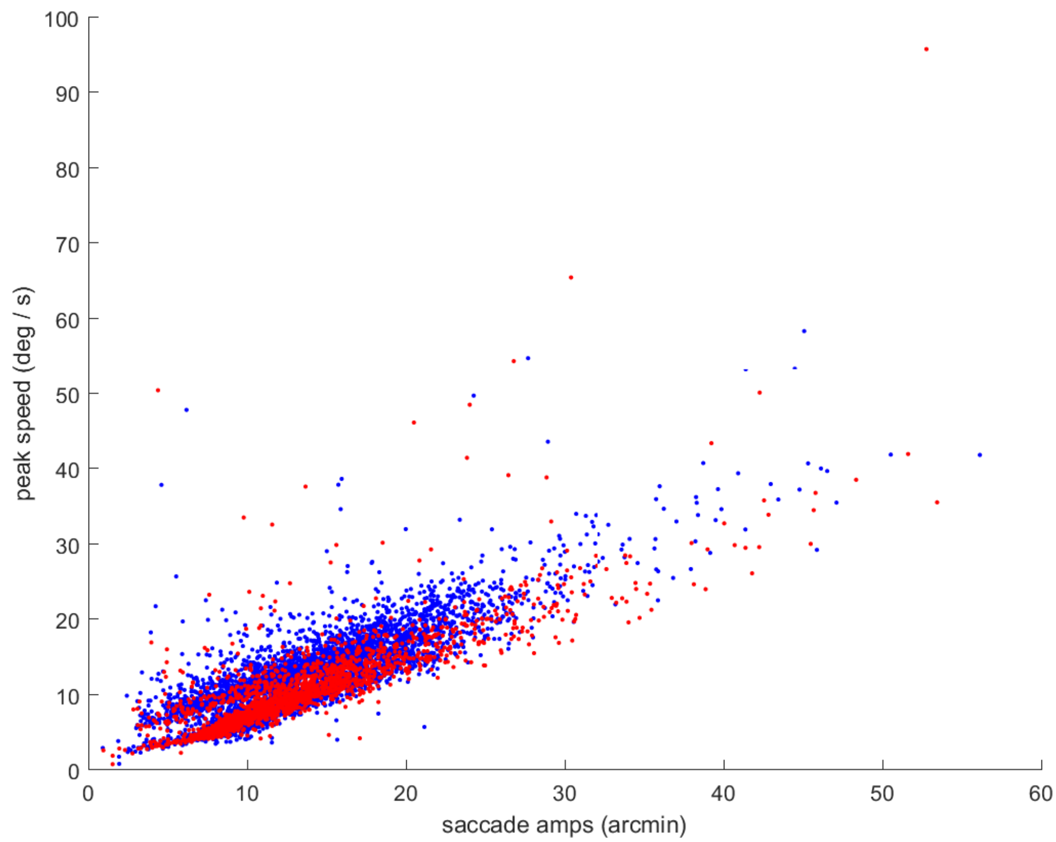


Figure 8: Main sequence for all subjects in the Snellen test. Blue dots are progressive saccades, red dots are regressive saccades.

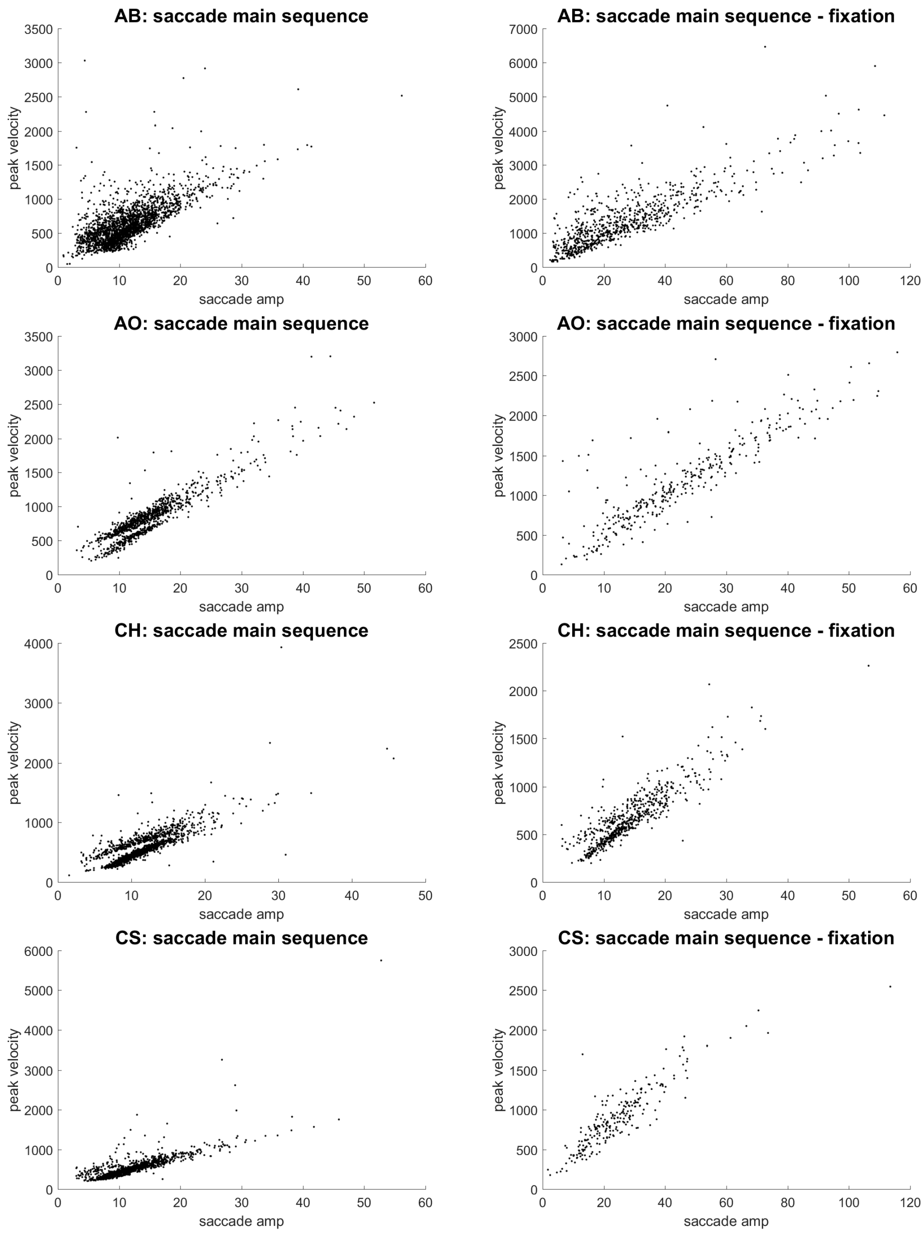


Figure 9: Saccade main sequences.... These seem odd.

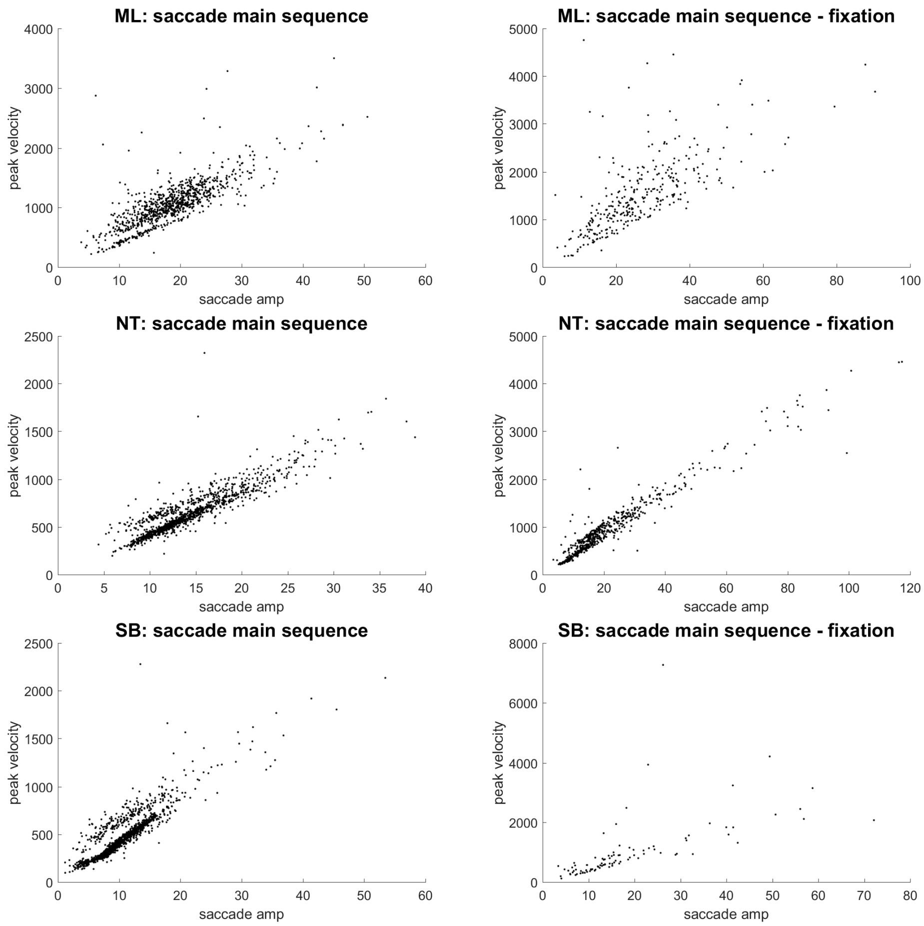


Figure 10: Saccade main sequences.... These seem odd

5.6 Drifts - All Subjects

Analyses were run in the main code controlling for drift duration.

	First 300ms			Last 300ms			whole period		
	Snellen	Fixation	p	Snellen	Fixation	p	Snellen	Fixation	p
Drift Duration							617.9 ± 53.3	256.8 ± 26.8	**0.016**
Drift Span	2.71±0.14	3.05±0.32	0.57	2.58±0.14	3.14±0.33	0.38	3.84±0.30	4.98±0.98	0.38
Drift Speed	39.42±2.14	45.12±2.24	**0.047**	38.99±2.17	45.11±2.29	**0.047**	39.15±2.17	44.87±2.27	**0.031**
Drift Curvature (mean)	26.69±1.85	23.01±1.73	0.375	28.64±1.47	21.92±1.48	**0.031**	30.66±1.61	22.30±1.36	**0.031**
Drift Curvature (median)	3.59±0.24	2.92±0.22	**0.016**	3.68±0.24	2.93±0.23	**0.016**	3.60±0.24	2.92±0.23	**0.016**
DiffCoeff (w/ Outlier)	26.45±2.69	53.0141±13.6797	0.078	23.28±2.64	64.11±15.7919	**0.031**	23.44±2.91	64.27 ±13.3899	**0.031**
DiffCoeff (w/o Outlier)	28.18±2.26	39.99±4.60	0.156	24.11±2.75	50.57±8.89	0.063	24.62±2.91	52.6352±7.25	0.063
DiffCoeff (saccsize-indv)	10.87±1.39	25.73±3.43	**0.016**	11.68±1.24	23.69±3.65	**0.047**	11.03±1.21	27.77±4.86	**0.031**
DiffCoeff (saccsize-all)	12.98±1.19	28.24±1.30	**0.000**	14.80±1.72	23.53±1.56	**0.000**	13.64±1.61	29.37±1.69	**0.000**
DiffCoeff (< 30)	10.79±1.33	31.21±4.27	**0.016**	11.96±1.18	28.47±5.57	**0.031**	10.83±1.21	33.00±5.90	**0.016**

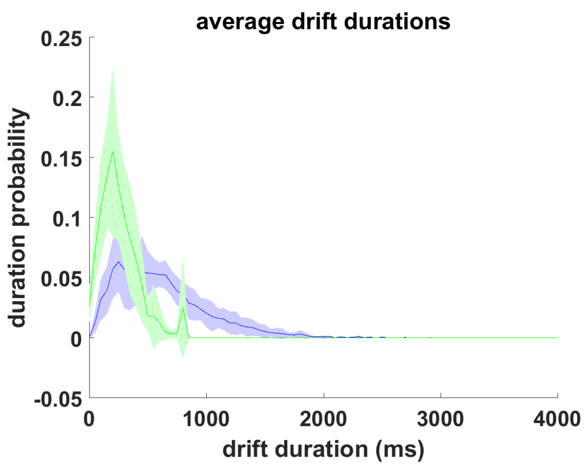


Figure 11: Drift durations.

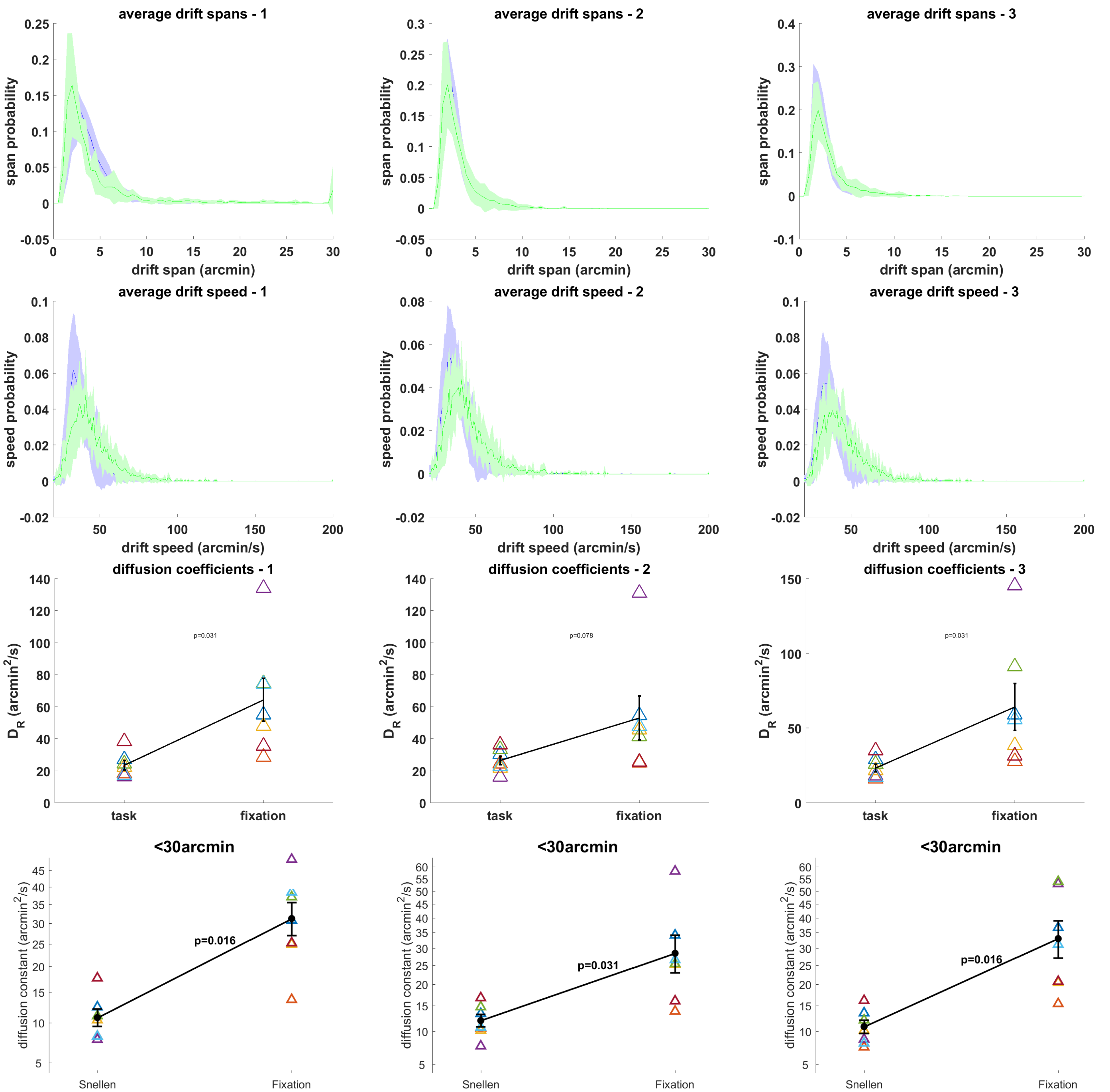


Figure 12: Drift characteristics for entire drift periods (left), the first 300ms of the drift (middle) and the last 300 ms (right). For the diffusion constants reported for drifts following saccades < 30 only, no retinal amplification factor has been applied.

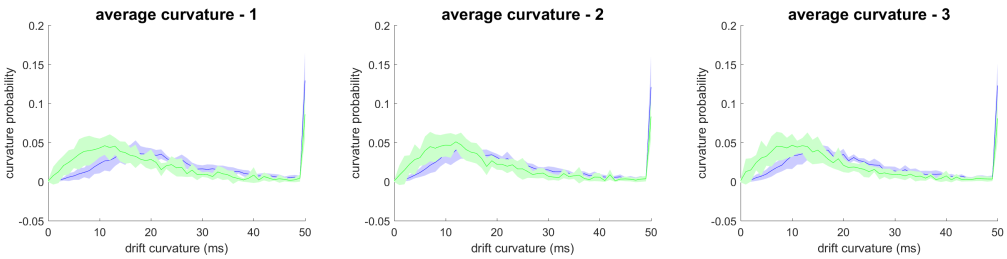


Figure 13: Drift curvature distributions for entire drift periods (left), the first 300ms of the drift (middle), and the last 300ms (right). (TOP): Median curvature of drift periods were taken. (BOTTOM - not shown): Mean curvature of drift periods were taken. UNITS ARE IN 1/ARCMIN.

Rather than average drift speed/curvature distributions across subjects, here I combine all data in order to run a KS-test:

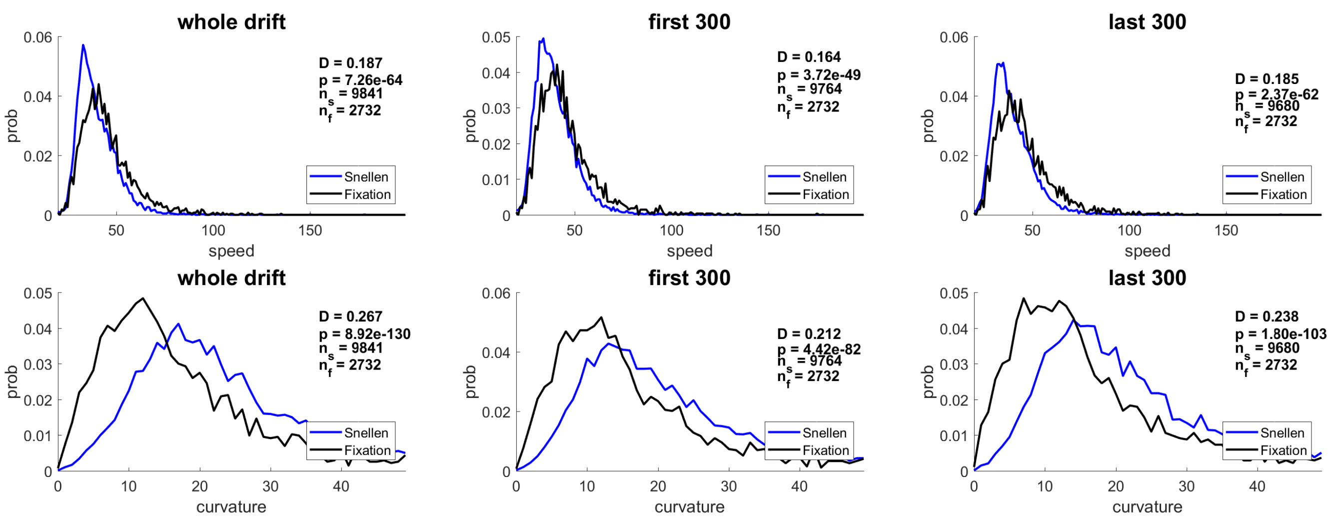


Figure 14: Drift speed and curvature distributions when data is pooled across subjects. Values shown are KS-test statistic (D) and p-value, and the number of drift segments used in test for both snellen and fixation. Pooled data are mean speed or curvature in individual drift segments (see driftcompare_all.m)

5.7 Drifts - control for preceding saccade amp

sandbox_control_driftbysaccsizeAll.m

To check that changes in drift diffusion were not caused by the different microsaccade characteristics, here we compared drift diffusions after controlling the distribution of the preceding saccade amplitude (thereby removing drifts that followed immediately from a blink or no-track).

This was done by measuring the empirical distribution of saccade amplitudes preceding drift periods during the Snellen test then randomly sampling drifts from the fixation period according to this distribution. Fixations were then uniformly sampled from the snellen task so that the same number of drift segments were used in computing the diffusion constant. The random sampling was repeated 100 times to estimate a distribution of diffusion constants. When data is combined across all subjects, approximately 530 drift segments were used in each computation. For an individual, the number of segments used was about 20-200.

The resulting saccade size distributions had the 'same' mean and variance between the snellen and fixation tasks (verified visually, not statistically).

As before, diffusion constants were computed over the three duration conditions.

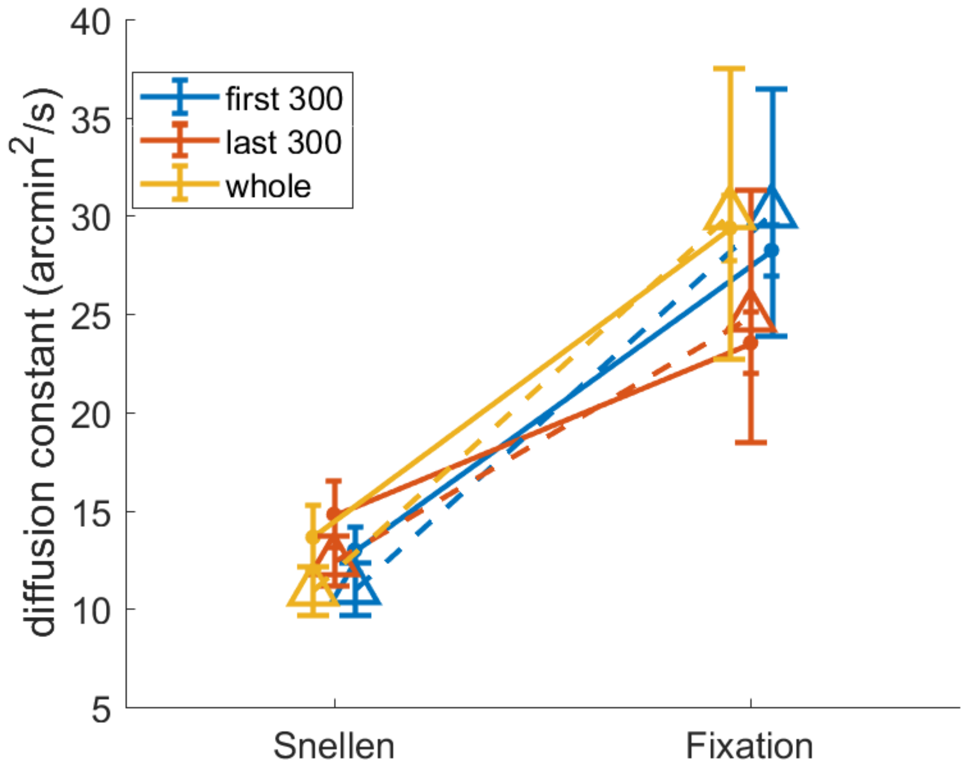


Figure 15: Diffusion constants computed with all subjects when preceding saccade sizes have the same distribution in the Snellen and Fixation conditions (see above text for details). Circles and solid lines show diffusion constants estimated the new way (mean + sem over different repeats of random samples). Triangles and dashed lines represent diffusion constants (mean + sem across subjects using all available trials).

Individual analyses: sandbox_control_driftbysaccsize.m

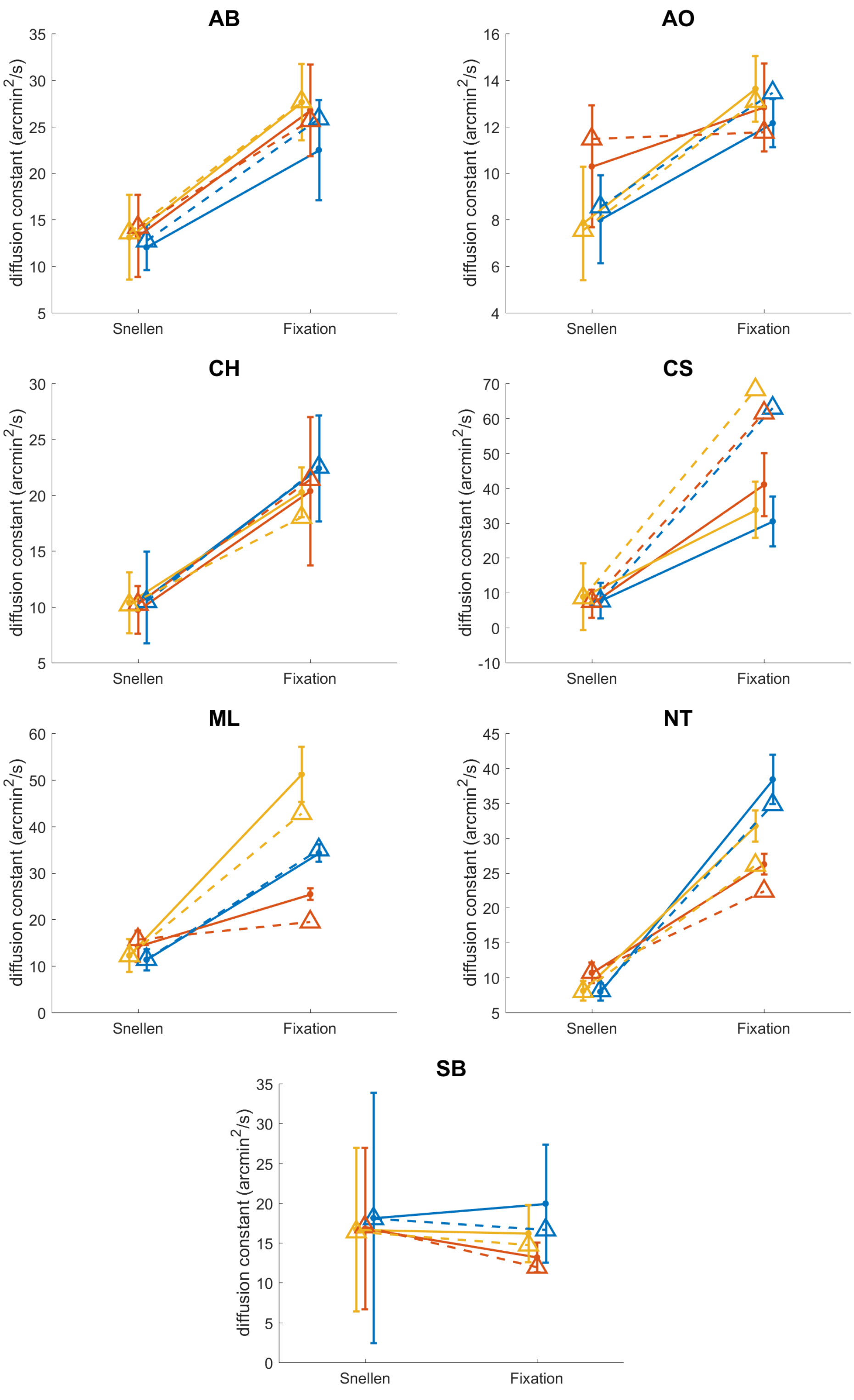


Figure 16: Same as above for each individual subject. (CS and SB had the fewest good drift segments in fixation for this (25ish trials) - other subjects ranged from 70-200 segments). Significant changes in diffusion constants in all three conditions - see drift table for p-values)

5.8 Drifts - Individuals

Kolomogorov-Smirnov tests were run for each individual subject to test the differences between the distributions of speed and curvature in the Snellen and fixation tasks. p-values are below. Diffusion constants were compared with permutation testing.

	Drift Speed			Drift Curvature			Diff Constant		
Subj	Whole	First	Last	Whole	First	Last	Whole	First	Last
AB	1.60e-08	7.23e-07	3.10e-08	1.67e-25	1.77e-19	1.57e-19	00	00	00
AO	3.15e-05	1.45e-04	1.76e-03	1.60e-02	9.61e-02	1.29e-02	00	3.40e-01	00
CH	1.97e-23	2.23e-20	7.78e-24	1.13e-21	8.55e-18	4.96e-21	00	00	00
CS	6.03e-104	3.43e-101	1.43e-95	1.89e-106	8.11e-103	4.94e-97	00	00	00
ML	3.53e-15	2.71e-05	1.96e-15	3.92e-12	1.07e-02	9.23e-12	00	7.00e-02	00
NT	1.04e-53	4.40e-38	7.16e-50	3.36e-61	1.29e-34	1.62e-49	00	00	00
SB	1.12e-01	2.87e-01	2.33e-01	2.49e-01	1.41e-01	3.89e-01	5.30e-01	8.90e-01	6.30e-01

Table 4: p-values for Kolmogorov-Smirnov tests comparing drift speed and curvature (median) distributions for each subject and p-vals for permutation testing the diffusion constant distributions. (Actually, when using *mean* curvature, SB does show significant differences in curvature.) The permutation testing and table of statistics are printed in diffusionconstants_ztest.m

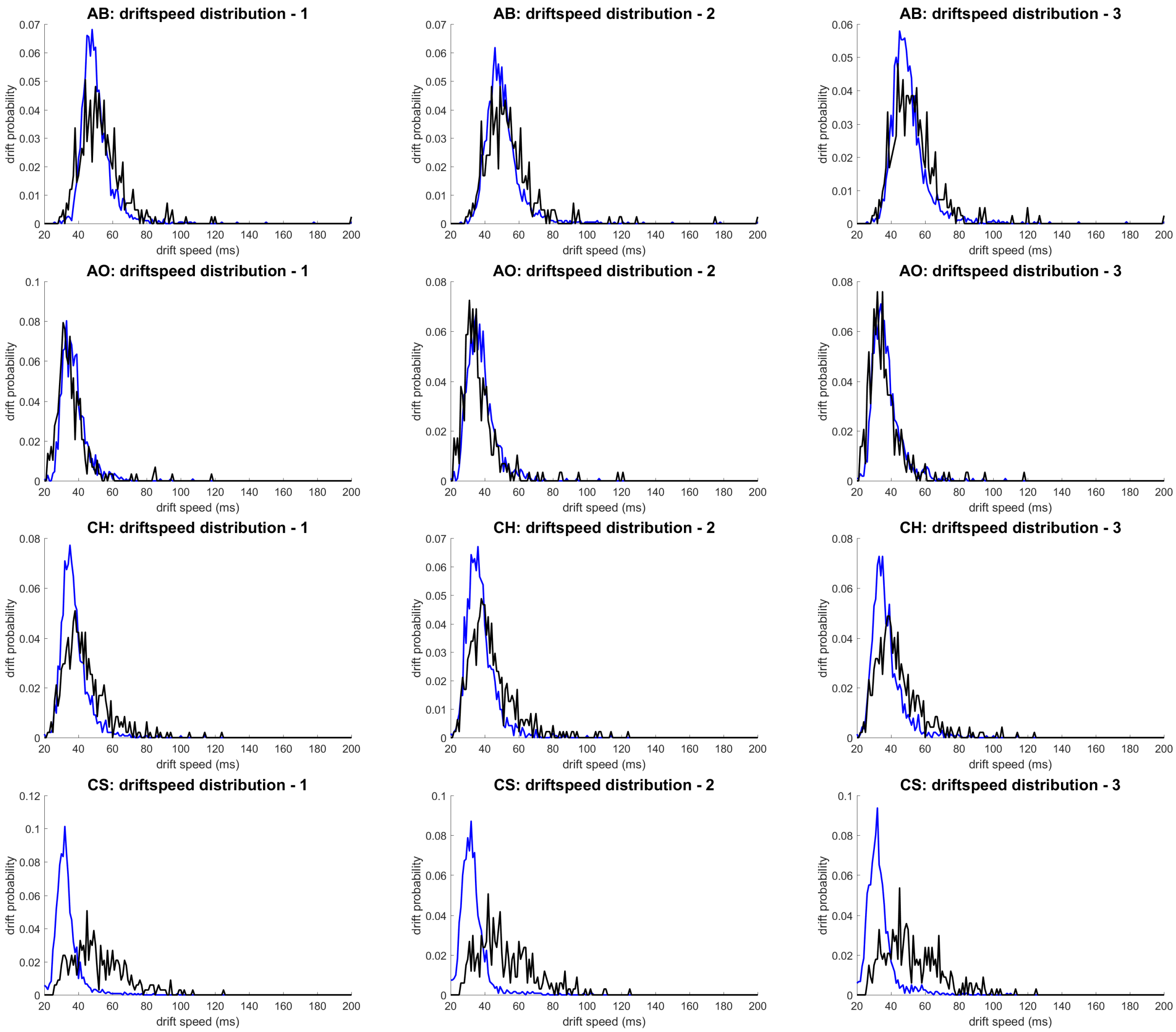


Figure 17: Individual drift speed distributions for entire drift periods (right), first 300ms (middle), and last 300ms (right). (p-values in table 4).

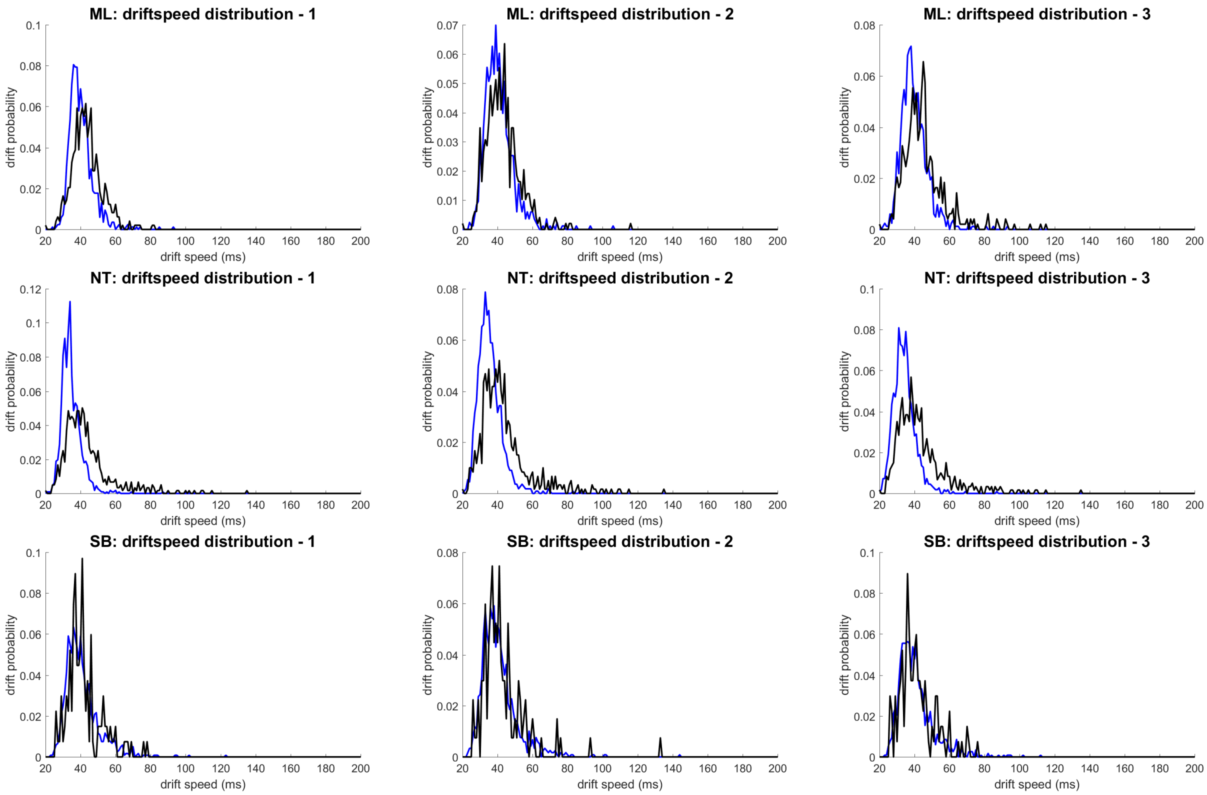


Figure 18: Individual drift speed distributions for entire drift periods (right), first 300ms (middle), and last 300ms (right). (p-values in table 4).

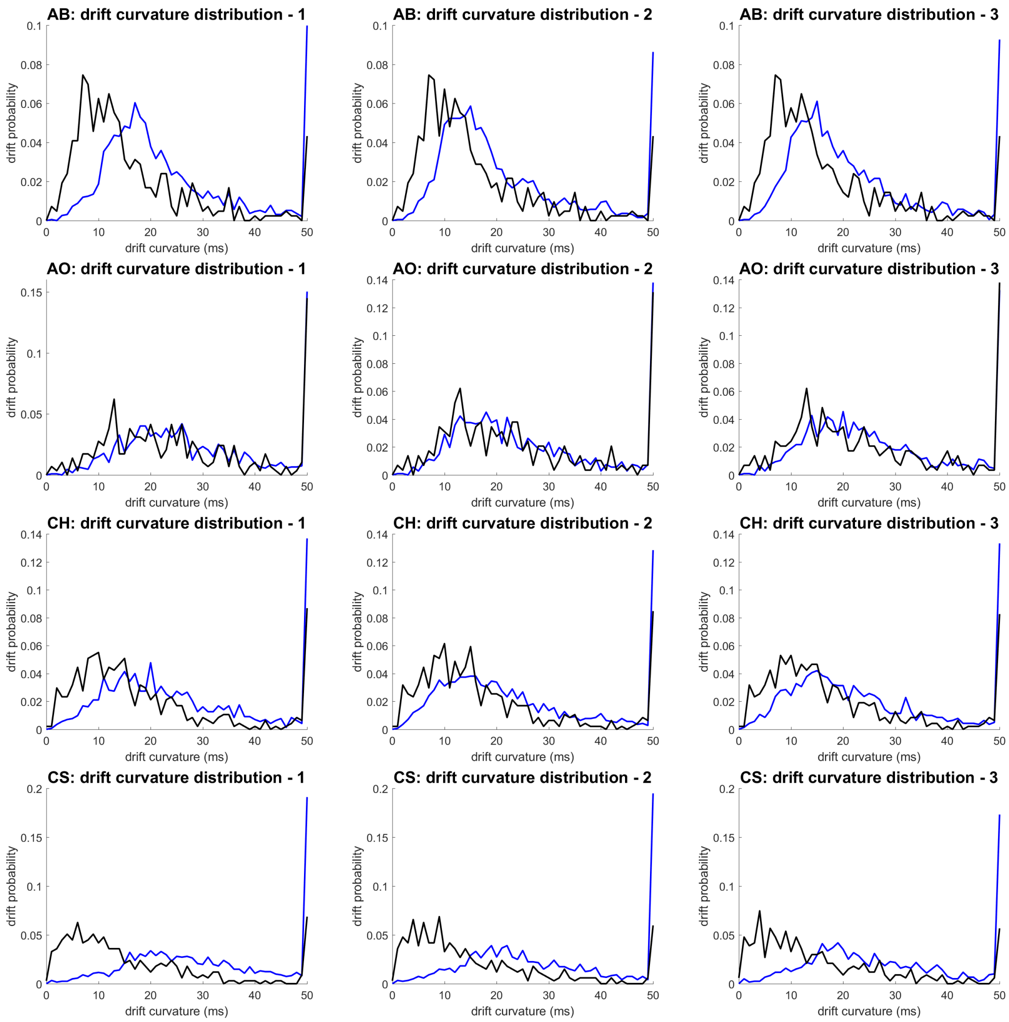


Figure 19: Individual drift curvature distributions for entire drift periods (right), first 300ms (middle), and last 300ms (right). (p-values in table 4).

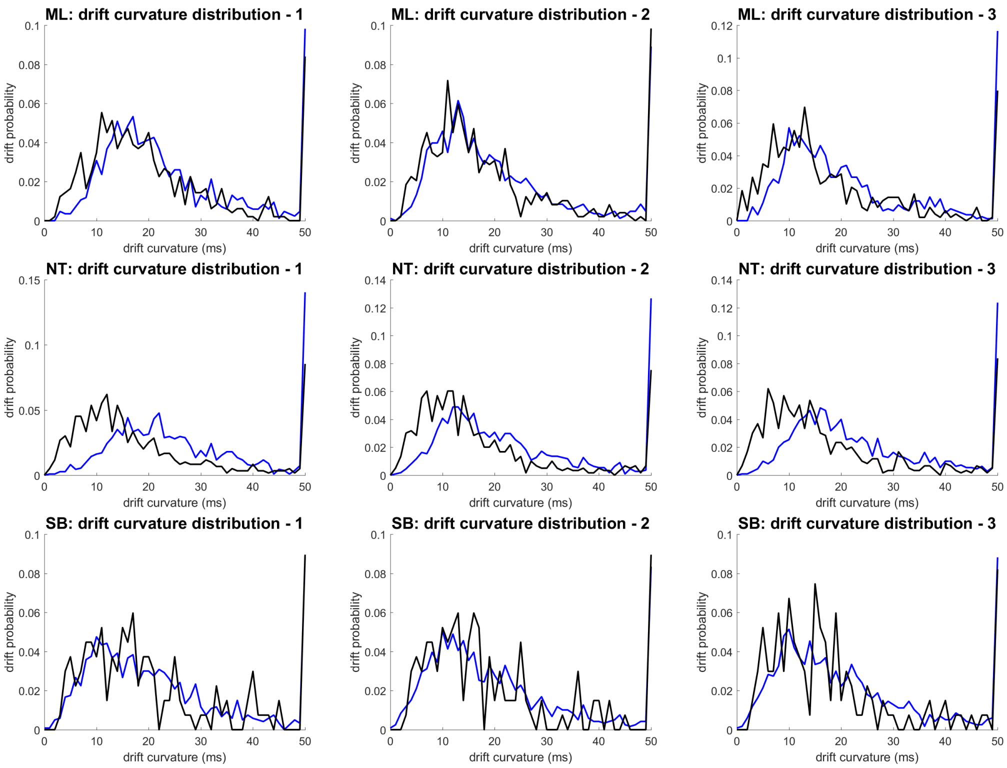


Figure 20: Individual drift curvature distributions for entire drift periods (right), first 300ms (middle), and last 300ms (right). (p-values in table 4).

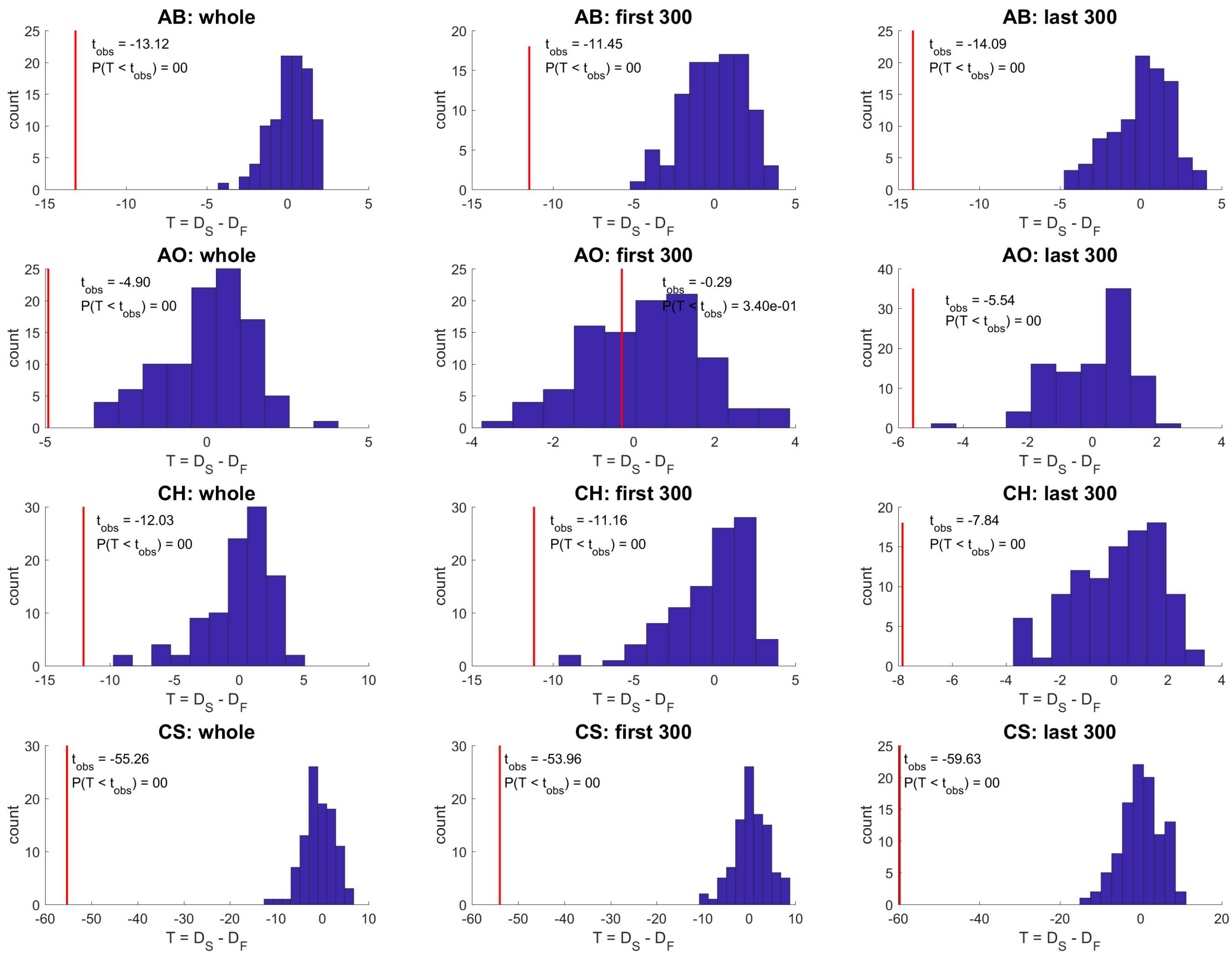


Figure 21: Permutation testing results for diffusion constants. diffusionconstants_ztest.m

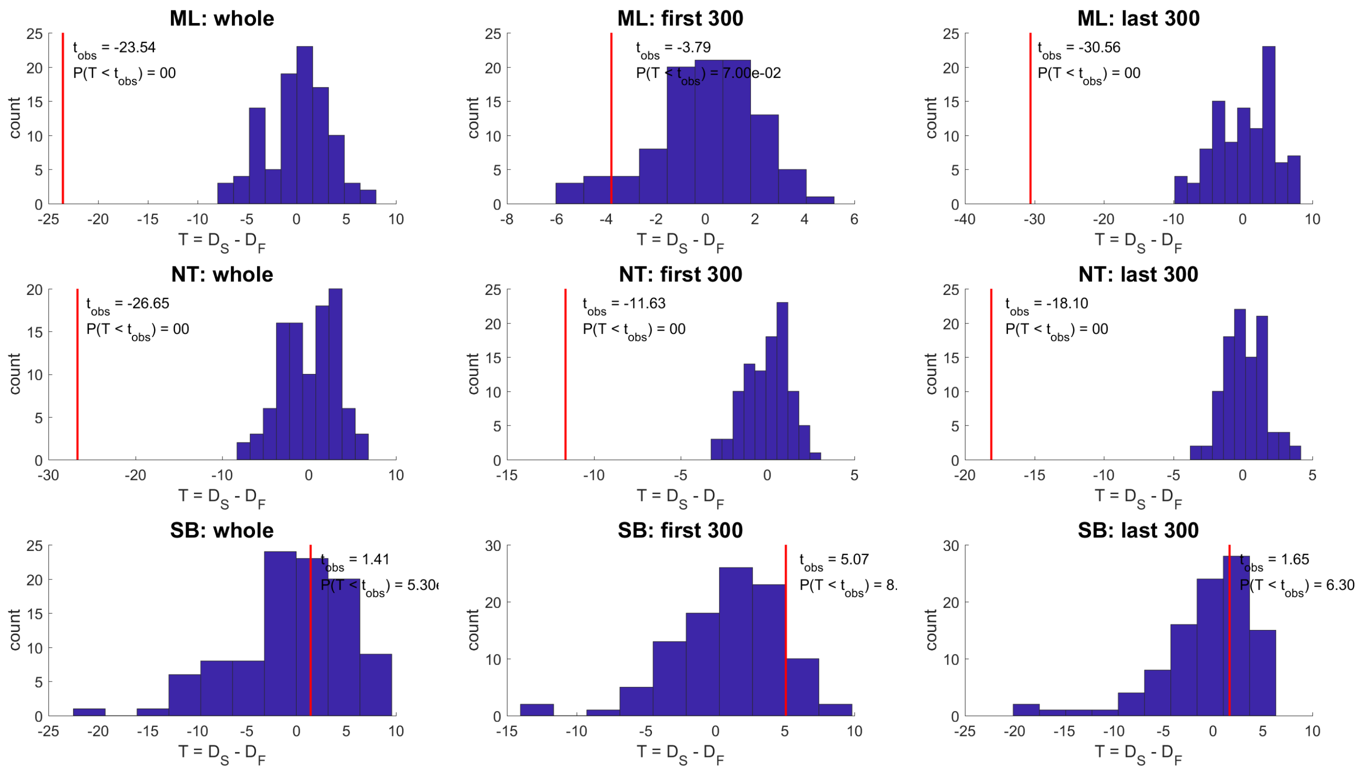


Figure 22: Permutation testing results for diffusion constants. diffusionconstants_ztest.m

5.9 Drifts: Power

5.9.1 Across subjects

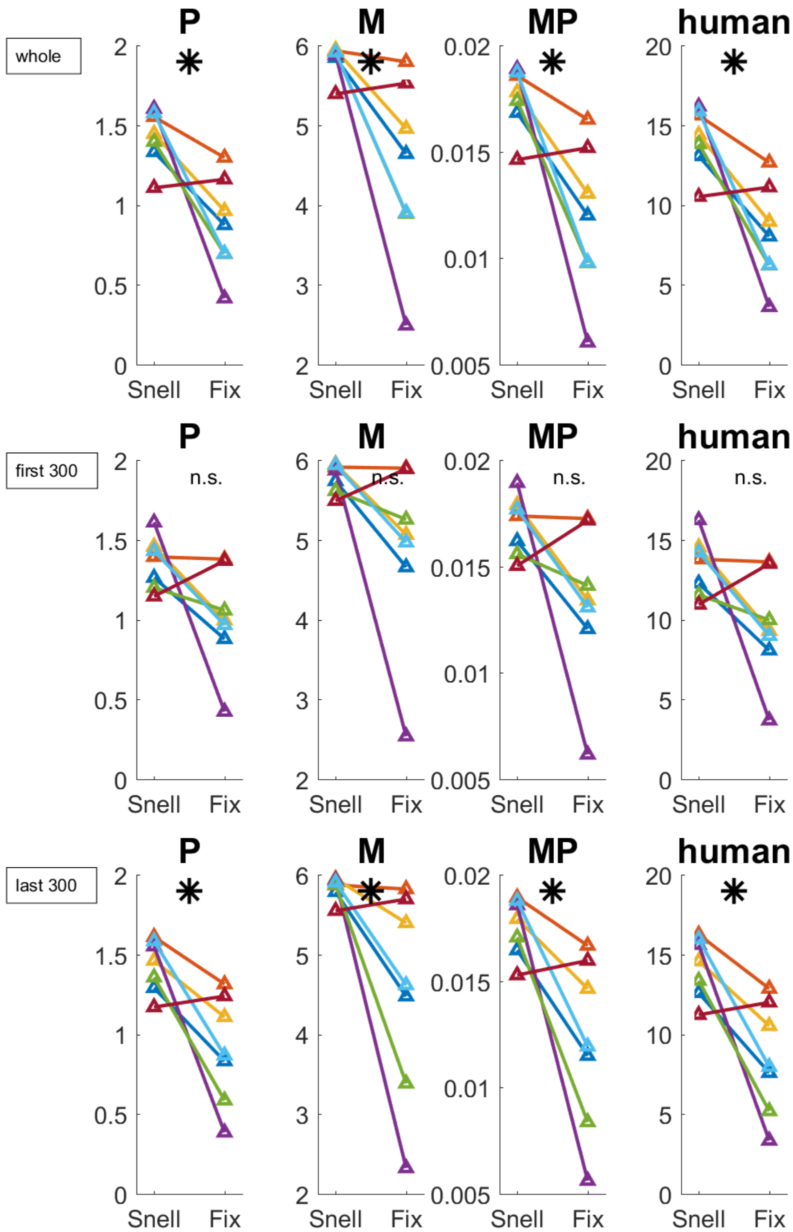


Figure 23: Sign-rank tests for power at 30cpd in Snellen vs. Fixation where power is computed for each individual based on their measured diffusion constant and one of 4 temporal sensitivity functions (>0Hz). P-values are in the table below. Retinal amplification factor not included.

Sensitivity	Whole	First 300	Last 300
P	**3.13e-02**	7.81e-02	**3.13e-02**
M	**3.13e-02**	7.81e-02	**4.69e-02**
MP	**3.13e-02**	7.81e-02	**3.13e-02**
human	**3.13e-02**	7.81e-02	**3.13e-02**

Table 5: P-values for sign rank tests across subjects for retinal power in Snellen vs. Fixation. Retinal amplification factor not included.

Sensitivity	Whole	First 300	Last 300
P	**3.13e-02**	7.81e-02	**3.13e-02**
M	**4.69e-02**	7.81e-02	7.81e-02
MP	**3.13e-02**	7.81e-02	**3.13e-02**
human	**3.13e-02**	7.81e-02	**3.13e-02**

Table 6: P-values for sign rank tests across subjects for retinal power in Snellen vs. Fixation. Retinal amplification factor not included, temporal frequencies < 2Hz not included.

5.10 Within individual

	P			M			MP			human		
AB	00	00	00	00	00	00	00	00	00	00	00	00
AO	00	1.00e-02	00	00	4.60e-01	4.70e-01	4.70e-01	4.60e-01	00	3.00e-01	00	00
CH	00	00	00	00	00	00	00	00	00	00	00	00
CS	00	00	00	00	00	00	00	00	00	00	00	00
ML	00	00	00	00	6.00e-02	6.00e-02	7.00e-02	6.00e-02	00	00	00	00
NT	00	00	00	00	00	00	00	00	00	00	00	00
SB	4.30e-01	4.30e-01	4.30e-01	4.30e-01	9.20e-01	9.40e-01	9.20e-01	9.20e-01	7.10e-01	7.00e-01	7.10e-01	7.10e-01

Table 7: Power was computed for one of 4 temporal sensitivity profiles with diffusion constants estimated for entire drift periods, first, or last 300 ms (subcolumns). Temporal frequencies down to 0Hz were included, power from drift were estimated by the Q-function (brownian motion model) at 30cpd. P-values were estimated by permutation testing (randomly selecting drift periods from Snellen or Fixation)

	P			M			MP			human		
AB	00	00	00	00	00	00	00	00	00	00	00	00
AO	1.00e-02	1.40e-01	1.00e-02	1.00e-02	4.30e-01	4.50e-01	4.30e-01	4.40e-01	00	7.10e-01	00	00
CH	00	00	00	00	00	00	00	00	00	00	00	00
CS	00	00	00	00	00	00	00	00	00	00	00	00
ML	00	00	00	00	7.00e-02	7.00e-02	7.00e-02	7.00e-02	00	00	00	00
NT	00	00	00	00	00	00	00	00	00	00	00	00
SB	4.70e-01	4.70e-01	4.70e-01	4.70e-01	9.10e-01	9.30e-01	9.10e-01	9.20e-01	5.00e-01	5.20e-01	5.00e-01	4.90e-01

Table 8: Power was computed for one of 4 temporal sensitivity profiles with diffusion constants estimated for entire drift periods, first, or last 300 ms (subcolumns). Temporal frequencies down to 2Hz were included, power from drift were estimated by the Q-function (brownian motion model) at 30cpd. P-values were estimated by permutation testing (randomly selecting drift periods from Snellen or Fixation)

5.11 All Eye Movements - distance to optotypes

sandbox.m

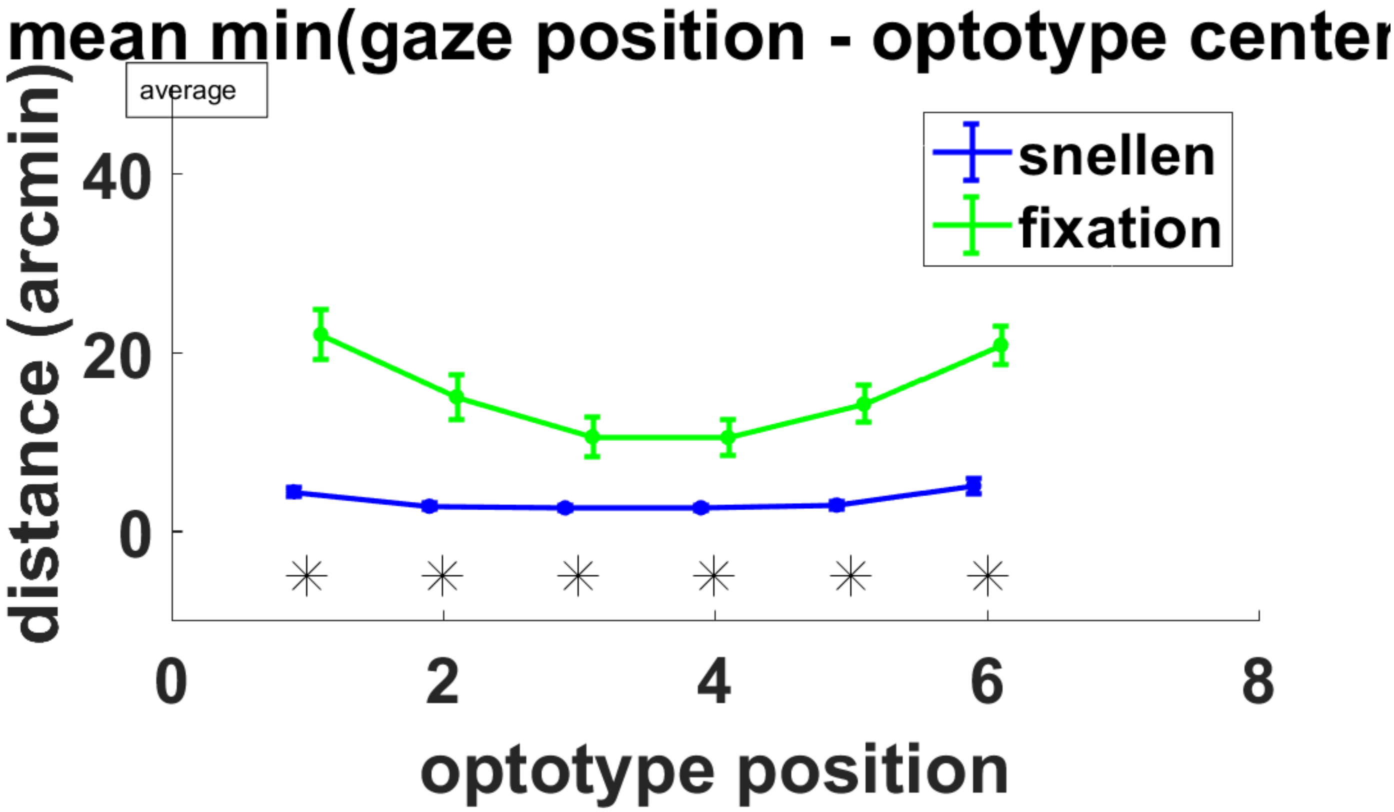


Figure 24: Average distance between gaze and nearest optotype. Gaze during Snellen was closer to each optotype on average than gaze during fixation (measured as though they were superimposed on the snellen stimulus).

	AB	AO	CH	CS	ML	NT	SB	avg
Snellen	2.46	2.16	3.68	2.84	4.41	2.72	4.63	3.27
Fixation	9.89	9.46	17.68	19.76	13.22	14.40	23.67	15.44

Table 9: Average distance (arcmin) between microsaccade landing and nearest optotype in each task (fixation microsaccades superimposed on snellen stimulus) were significantly different (sign rank, $p = 0.0156$)

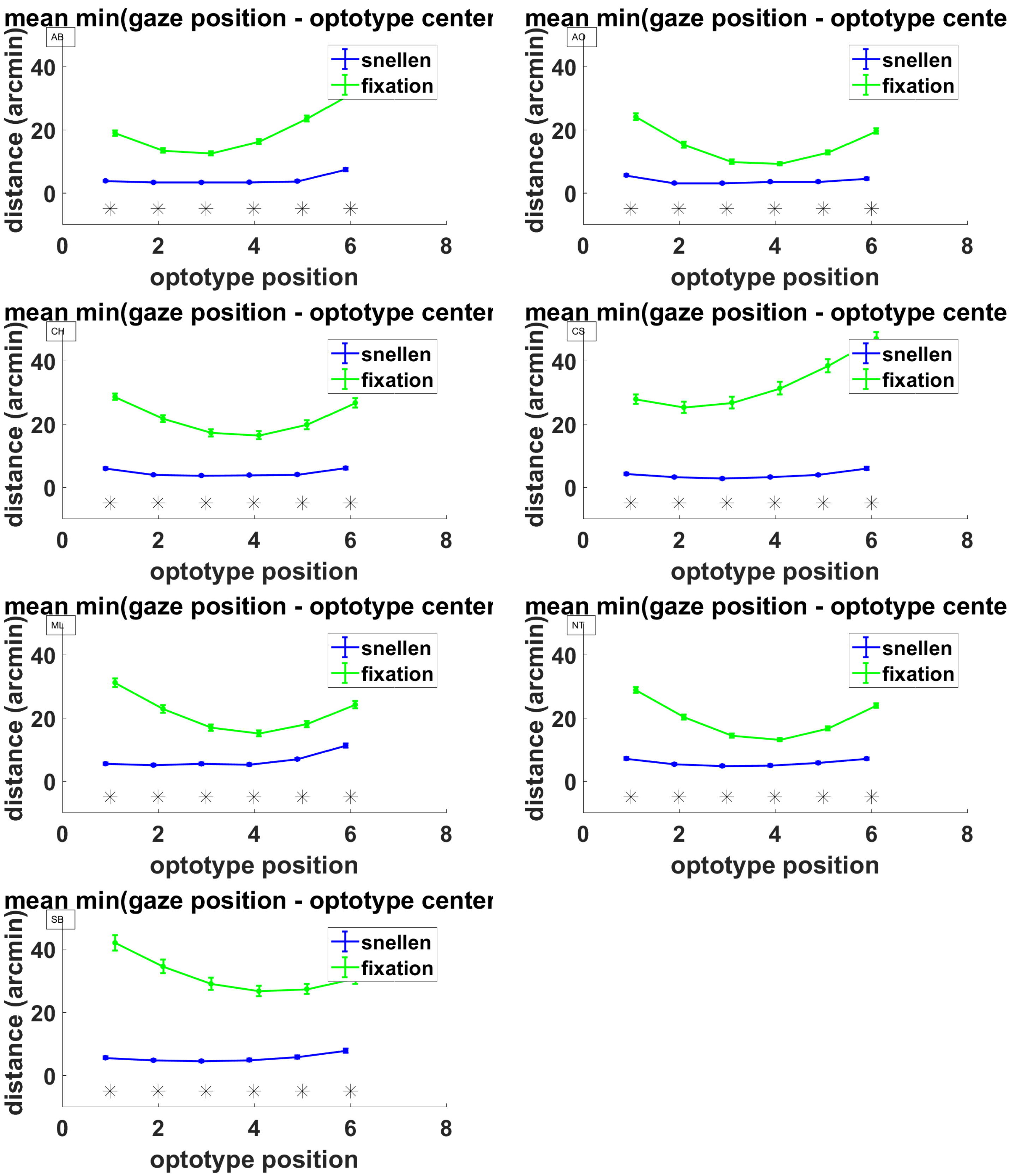


Figure 25: Same as above for each individual subject.

6 Behavioral Results

6.1 Contrast Threshold Estimation

Pest level (fractional gray level) and Weber thresholds are reported. The following table is generated by the script
`https://gitlab.com/jintoy/EyeChartExperiment/blob/master/Analysis/printNumberOfTrials.m`
Psychometric functions are fit following Wichmann and Hill's method. Median and MAD of bootstrap threshold estimates are shown.

	Pest Level		Weber	
Subject	Normal	Stab	Normal	Stab
AB	0.531±0.027	1.171±0.056	0.529±0.027	1.172±0.055
AO	0.384±0.007	> 10	0.384±0.008	> 10
CH	0.472±0.008	1.349±0.338	0.470±0.008	1.349±0.337
CS	0.563±0.013	1.590±0.492	0.565±0.012	1.588±0.494
ML	0.579±0.019	1.625±0.208	0.580±0.020	1.623±0.208
NT	0.696±0.031	1.434±0.137	0.694±0.031	1.435±0.137
SB	0.809±0.026	4.378±3.328	0.808±0.027	4.376±3.329

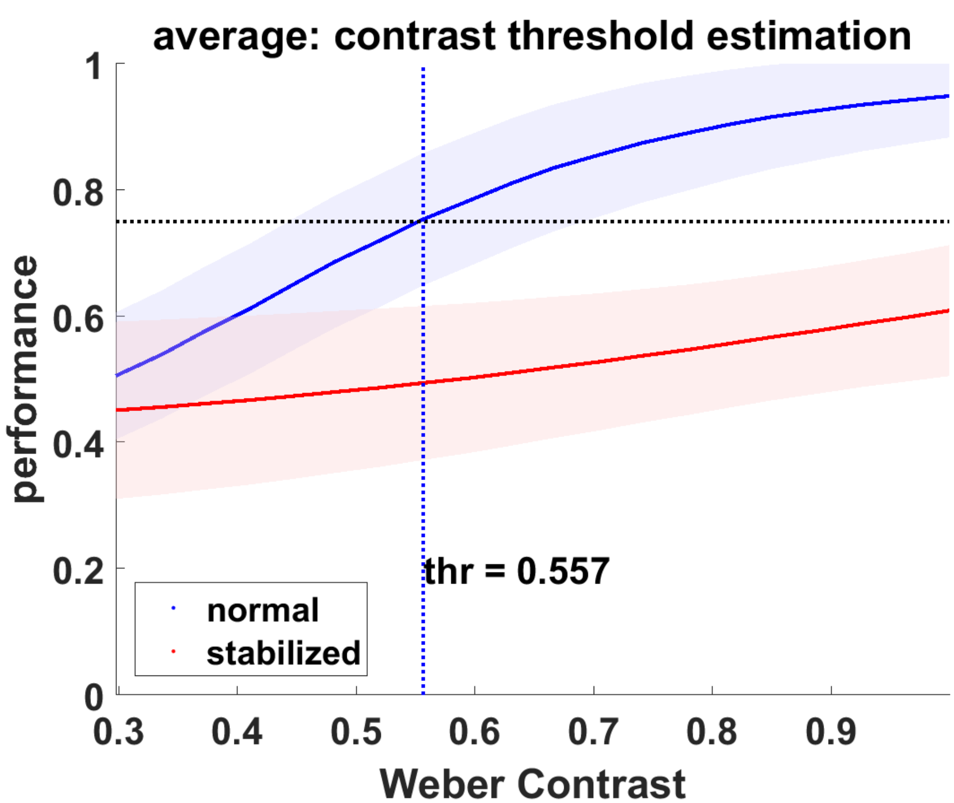


Figure 26: Average of psychometric functions for contrast.

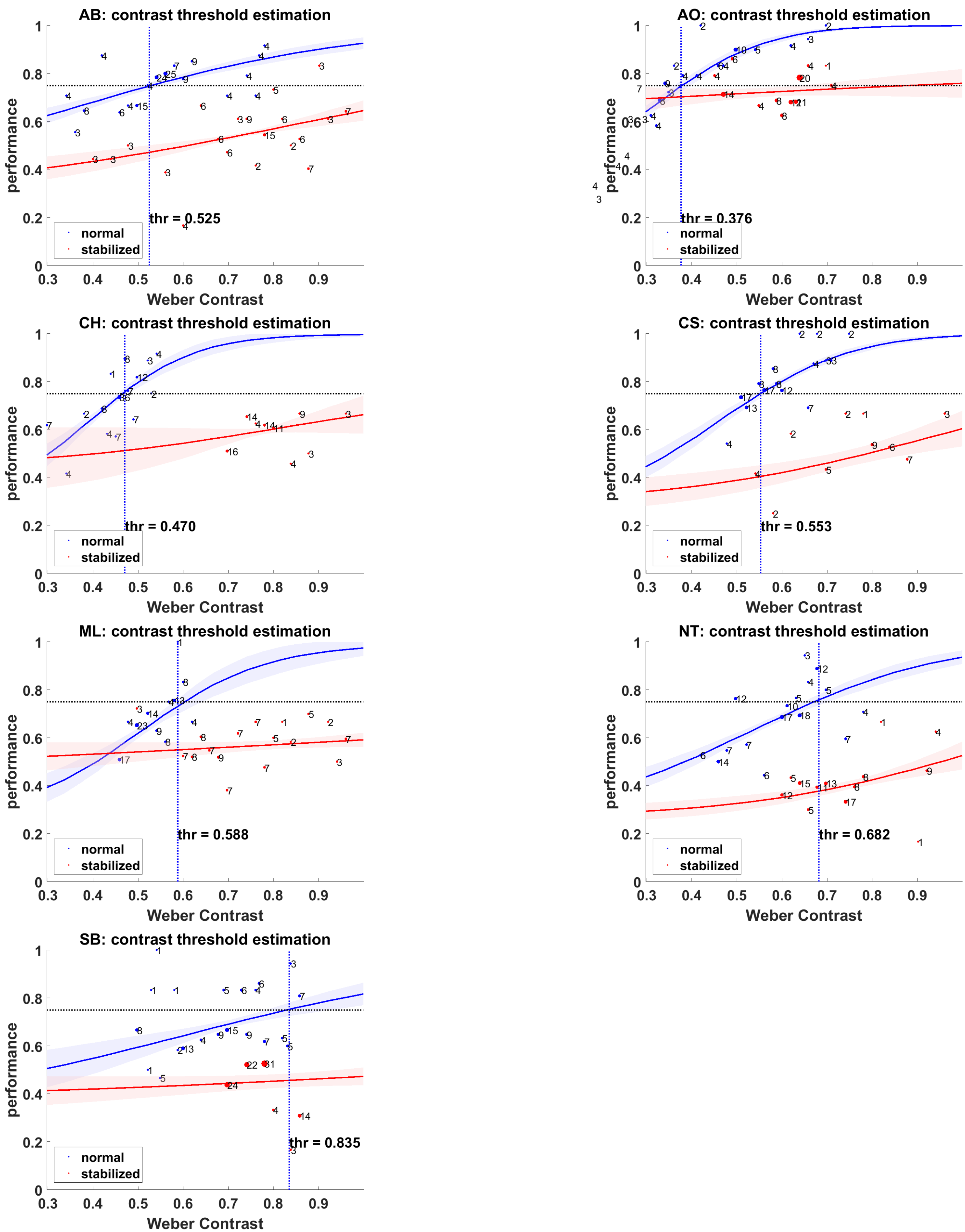


Figure 27: Individual psychometric functions over contrast.

6.2 Size Threshold Estimation

Size psychometric functions were fit using both a cumulative normal (Wichmann and Hill) and a sigmoid, which is used in the manuscript. Both are shown here. The sigmoid fitting is done in the code in `https://gitlab.com/jintoy/EyeChartExperiment/blob/master/Analysis/compareSizeFits.m` and not in the main analysis code. (As of August 3, 2017, this is no longer true. The main analysis code is fitting a sigmoid.) The following table is generated by the script `https://gitlab.com/jintoy/EyeChartExperiment/blob/master/Analysis/printNumberOfTrials.m`, though thresholds from the sigmoid fit were added separately.

	Cumulative Normal		Sigmoid
Subject	Acuity Thr	Acuity LOSS	
AB	0.203±0.015	0.178±0.015	0.2396
AO	0.078±0.021	0.052±0.021	0.0826
CH	0.178±0.009	0.153±0.009	0.1612
CS	0.194±0.014	0.169±0.014	0.1699
ML	0.159±0.017	0.134±0.017	0.1360
NT	0.193±0.008	0.168±0.008	0.1752
SB	0.135±0.016	0.109±0.016	0.1255

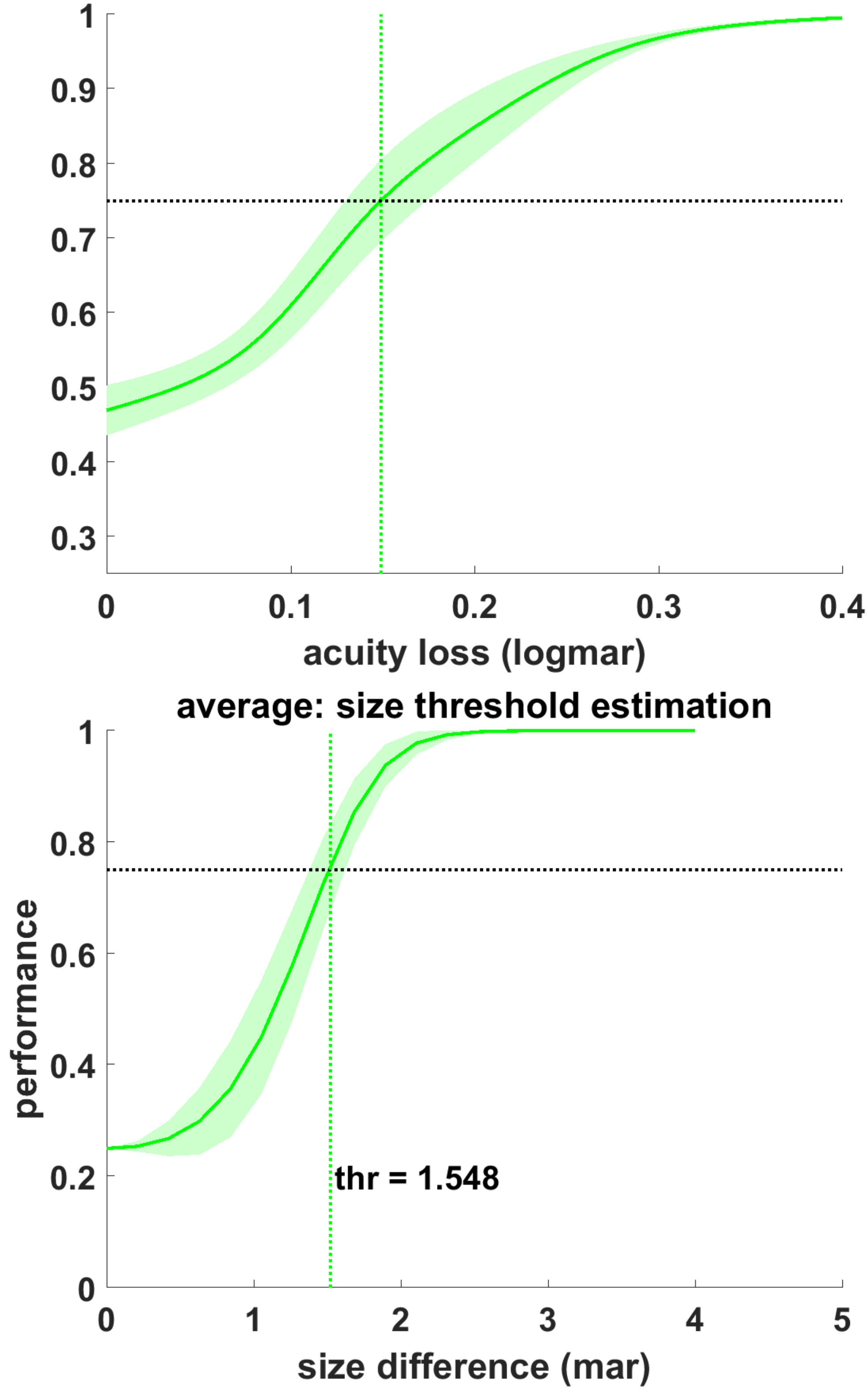


Figure 28: Average of psychometric functions for acuity LOSS. Sigmoid (left) and Weibull function (right)

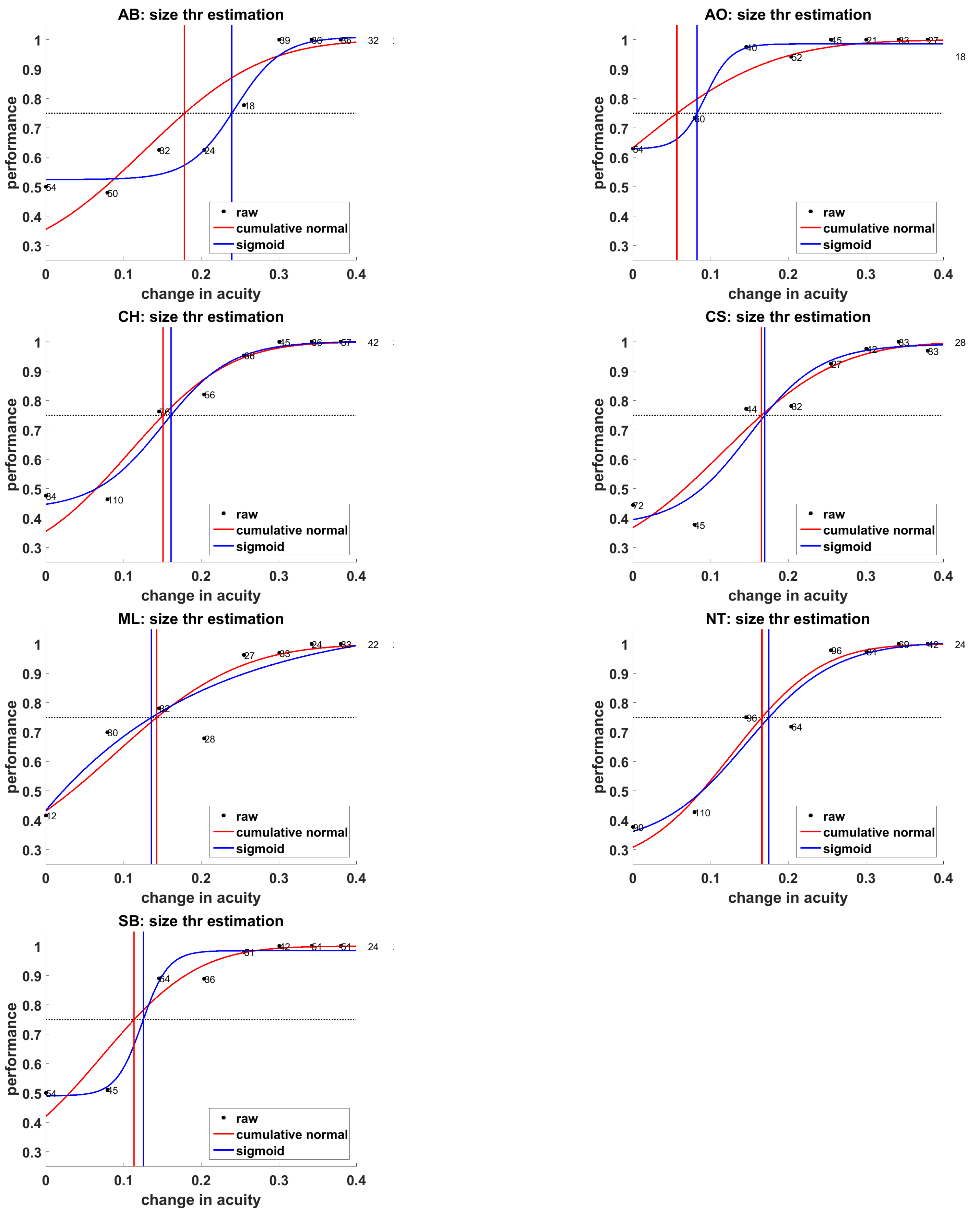


Figure 29: Individual psychometric functions over acuity loss.

6.2.1 Weibull fitting

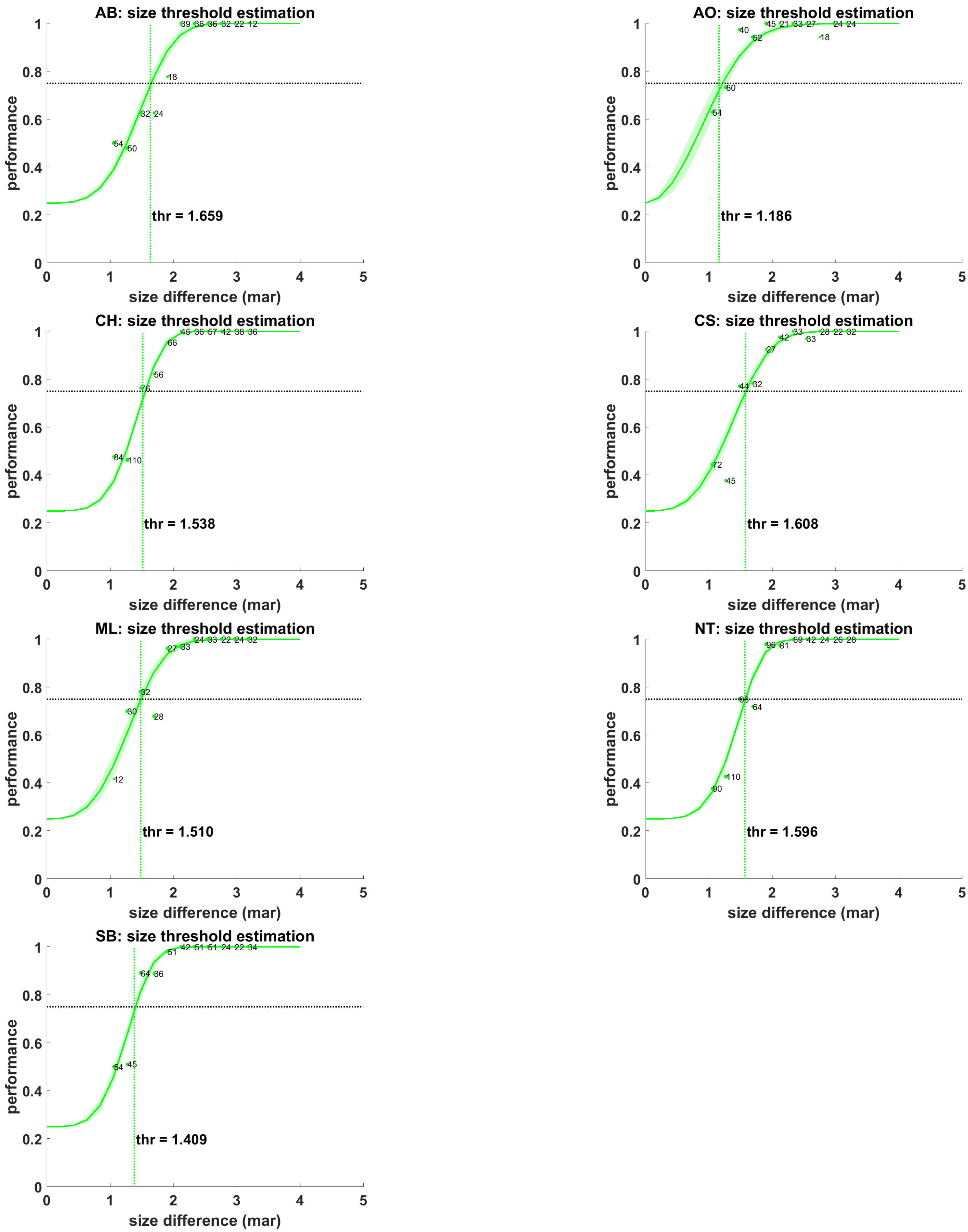


Figure 30: Individual psychometric functions over acuity loss. (Weibull fitting)

6.3 Performance by Position (20/20)

Subject	Normal	Stabilized	Control
AB	115	31	
AO	84	33	41
CH	105	14	
CS	105	25	
ML	105	58	
NT	91	110	233
SB	87	107	

Table 10: Number of trials near normal contrast threshold.

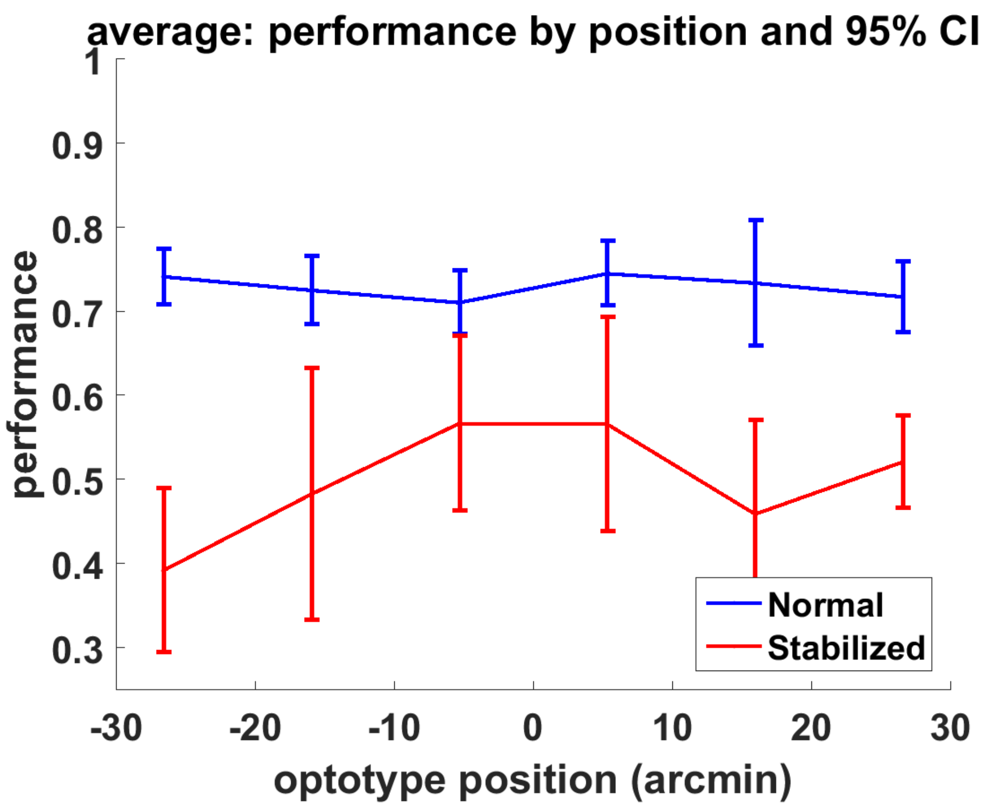


Figure 31: Average performance by position.

Subject	Normal							Stabilized						
	1	2	3	4	5	6	all	1	2	3	4	5	6	all
AB	0.76	0.70	0.77	0.80	0.81	0.73	0.76	0.35	0.42	0.42	0.55	0.58	0.48	0.47
AO	0.78	0.64	0.70	0.69	0.83	0.73	0.73	0.64	0.85	0.79	0.91	0.61	0.58	0.73
CH	0.81	0.81	0.70	0.70	0.66	0.71	0.73	0.36	0.29	0.43	0.64	0.64	0.50	0.48
CS	0.70	0.73	0.79	0.78	0.77	0.82	0.77	0.24	0.32	0.60	0.44	0.36	0.64	0.43
ML	0.70	0.72	0.65	0.70	0.57	0.65	0.66	0.48	0.64	0.69	0.50	0.40	0.52	0.54
NT	0.75	0.77	0.68	0.80	0.68	0.66	0.72	0.35	0.39	0.48	0.42	0.27	0.41	0.39
SB	0.71	0.69	0.68	0.75	0.82	0.72	0.73	0.33	0.48	0.56	0.50	0.36	0.52	0.46
average	0.74±0.02	0.73±0.02	0.71±0.02	0.74±0.02	0.73±0.04	0.72±0.02	0.73±0.03	0.39±0.05	0.48±0.07	0.57±0.05	0.57±0.06	0.46±0.06	0.52±0.03	0.50±0.11

(statistical tests in script ttestByPosition.m)

Position	1	2	3	4	5	6
p-value	**0.0156**	**0.047**	0.078	0.078	**0.0156**	**0.0156**

Table 11: Sign-rank test for performance difference at each position in normal vs stabilized conditions.

6.3.1 anova results

One-way anovas: (Kruskal-Wallis anova produced qualitatively similar results)

- Effect of position on normal performance: $p = .8845, F_{5,36} = 0.34$
- Effect of position on stabilized performance: $p = 0.220, F_{5,36} = 1.48$
- Effect of position on change in performance: $p = 0.258, F_{5,36} = 1.37$

Two-way anova: effect of position and condition (normal vs stabilized)

- effect of position: $p = 0.366, F_{5,72} = 1.1030$
- **effect of condition:** $p < 10^{-13}, F_{1,72} = 87.9564$
- interaction: $p = 0.194, F_{5,72} = 1.5209$

6.3.2 Individual figures

The following figures and z-tests were done in perfByPosition_ztest.m.

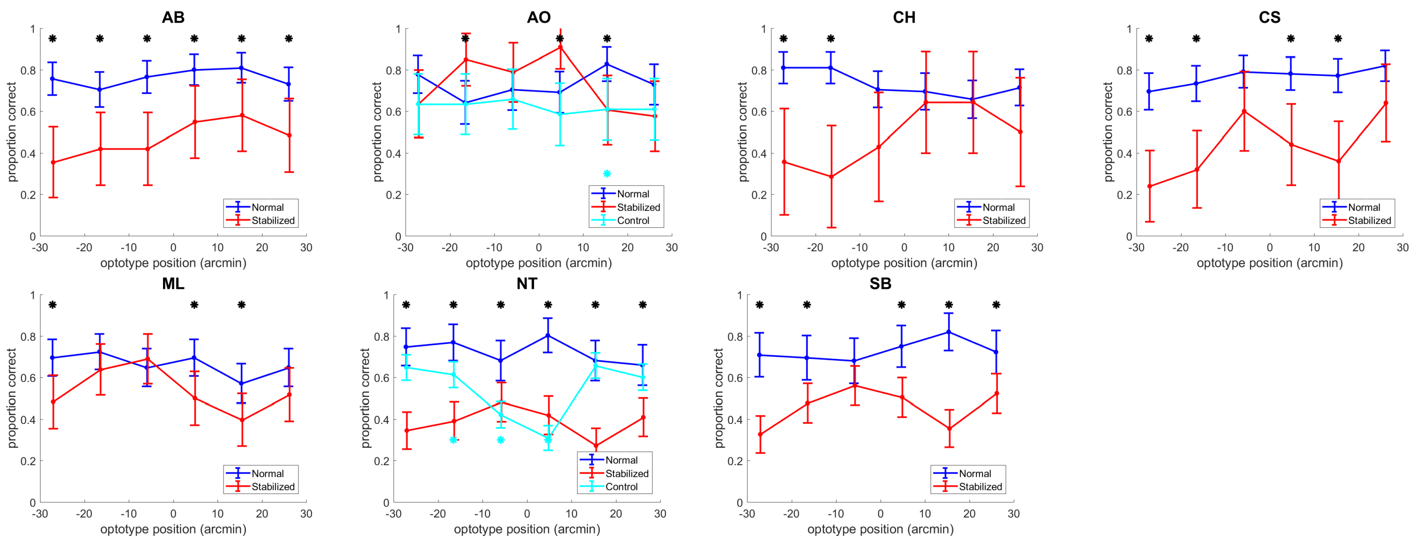


Figure 32: Individual performance by position. Error bars show 95% confidence intervals on the binomial estimator. z-tests: Black stars mark significant differences between normal and stabilized. Cyan stars mark significant differences between normal and control task. (Table of statistics below).

Subject	1	2	3	4	5	6
AB	z=4.01, **p=0.000**	z=2.73, **p=0.006**	z=3.48, **p=0.000**	z=2.63, **p=0.009**	z=2.40, **p=0.016**	z=2.39, **p=0.017**
AO	z=1.32, p=0.187	z=-1.96, **p=0.050**	z=-0.68, p=0.494	z=-2.21, **p=0.027**	z=2.28, **p=0.023**	z=1.37, p=0.171
CH	z=3.37, **p=0.001**	z=3.91, **p=0.000**	z=1.76, p=0.078	z=0.09, p=0.928	z=-0.19, p=0.846	z=1.32, p=0.187
CS	z=3.96, **p=0.000**	z=3.67, **p=0.000**	z=1.73, p=0.084	z=3.15, **p=0.002**	z=3.76, **p=0.000**	z=1.69, p=0.092
ML	z=2.51, **p=0.012**	z=0.96, p=0.337	z=-0.37, p=0.711	z=2.30, **p=0.022**	z=1.97, **p=0.048**	z=1.46, p=0.144
NT	z=5.54, **p=0.000**	z=5.24, **p=0.000**	z=2.70, **p=0.007**	z=5.37, **p=0.000**	z=5.65, **p=0.000**	z=3.39, **p=0.001**
SB	z=4.85, **p=0.000**	z=2.73, **p=0.006**	z=1.45, p=0.146	z=3.13, **p=0.002**	z=5.96, **p=0.000**	z=2.51, **p=0.012**

Table 12: Results of z-tests for normal vs stabilized conditions at each optotype position corresponding to figure 32

6.4 Perf by Position near 20/30

Performance by position near size threshold.
`https://gitlab.com/jintoy/EyeChartExperiment/blob/master/Analysis/plotPerfByPositionSize.m`

Subject	# Trials
AB	12
AO	12
CH	33
CS	19
ML	-
NT	40
SB	25

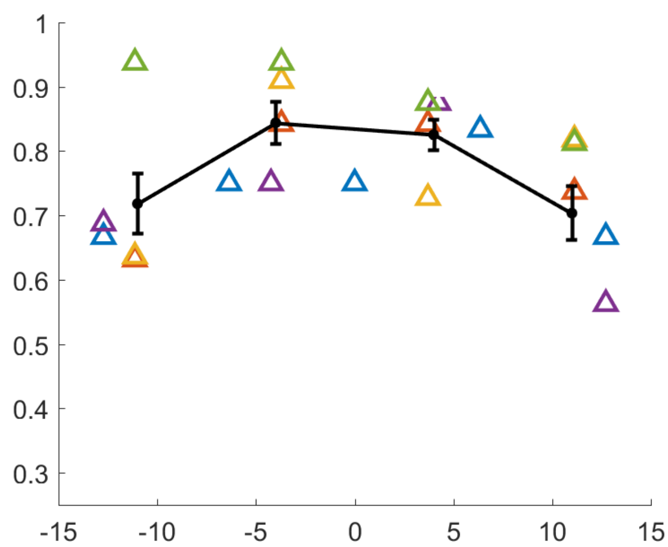


Figure 33: Average performance by eccentricity near size threshold.

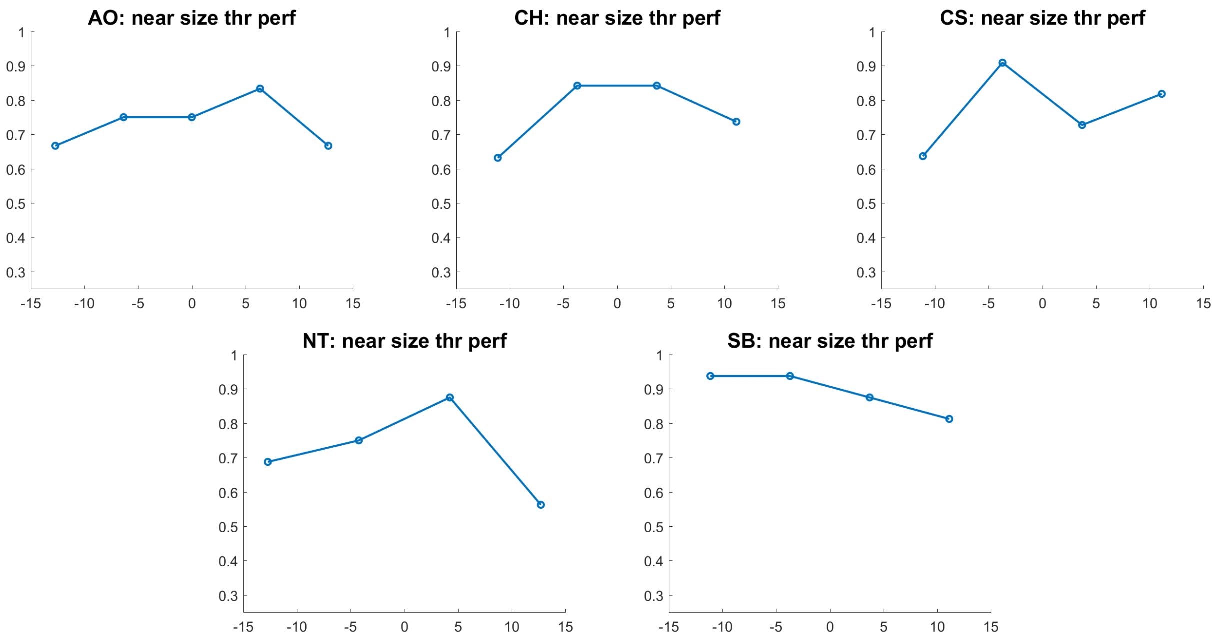


Figure 34: Individual performance by position. ML was skipped for not enough data.

6.5 Perf by distance to optotype

6.5.1 Saccade landing

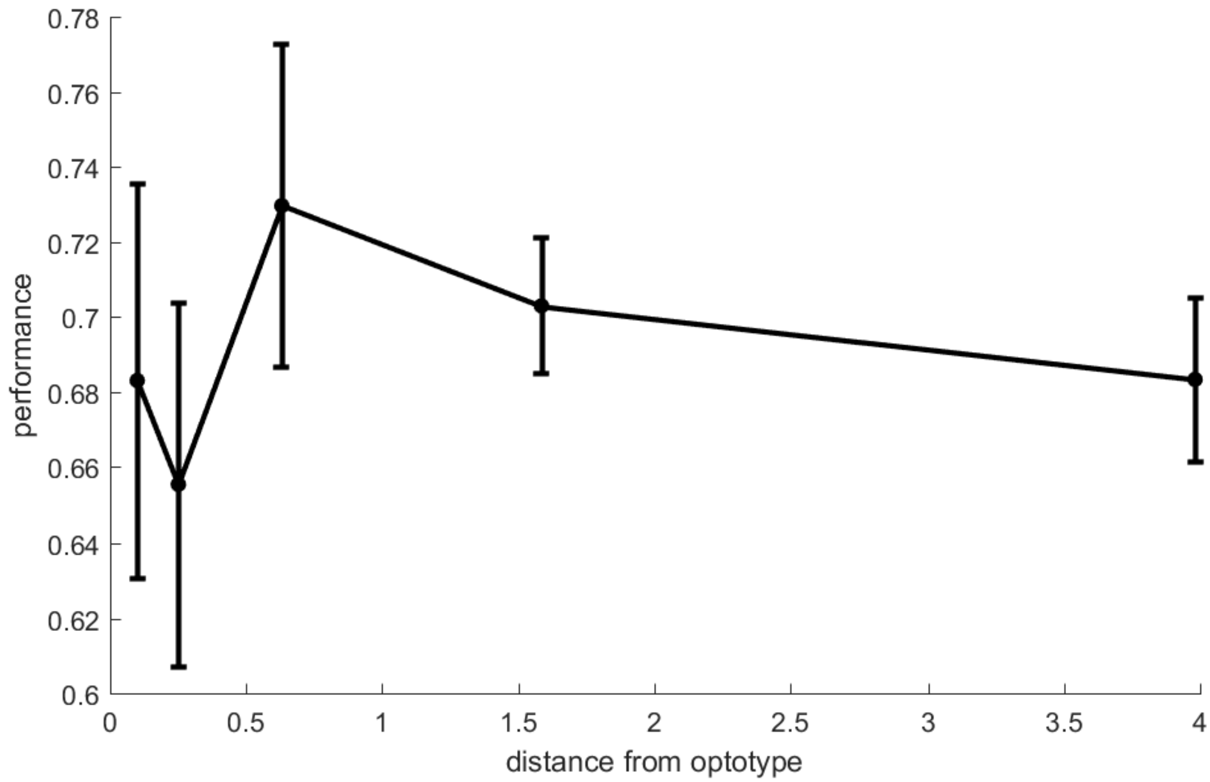


Figure 35: Performance at optotypes binned by minimum distance of saccade landing (including 50ms after landing). No clear trend here and no main effect with ANOVA.

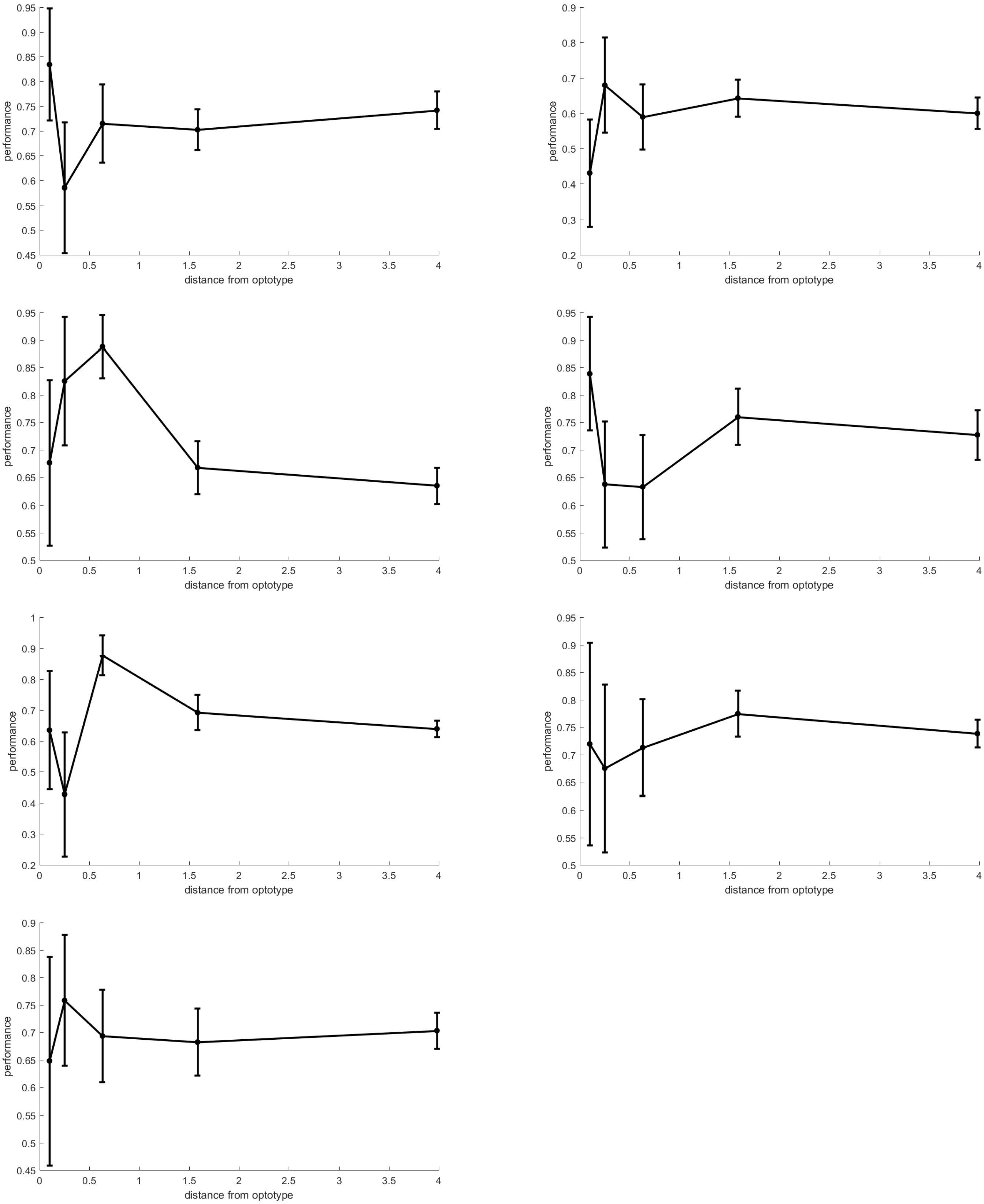


Figure 36: Same as above for each individual subject.

6.5.2 All eye movements

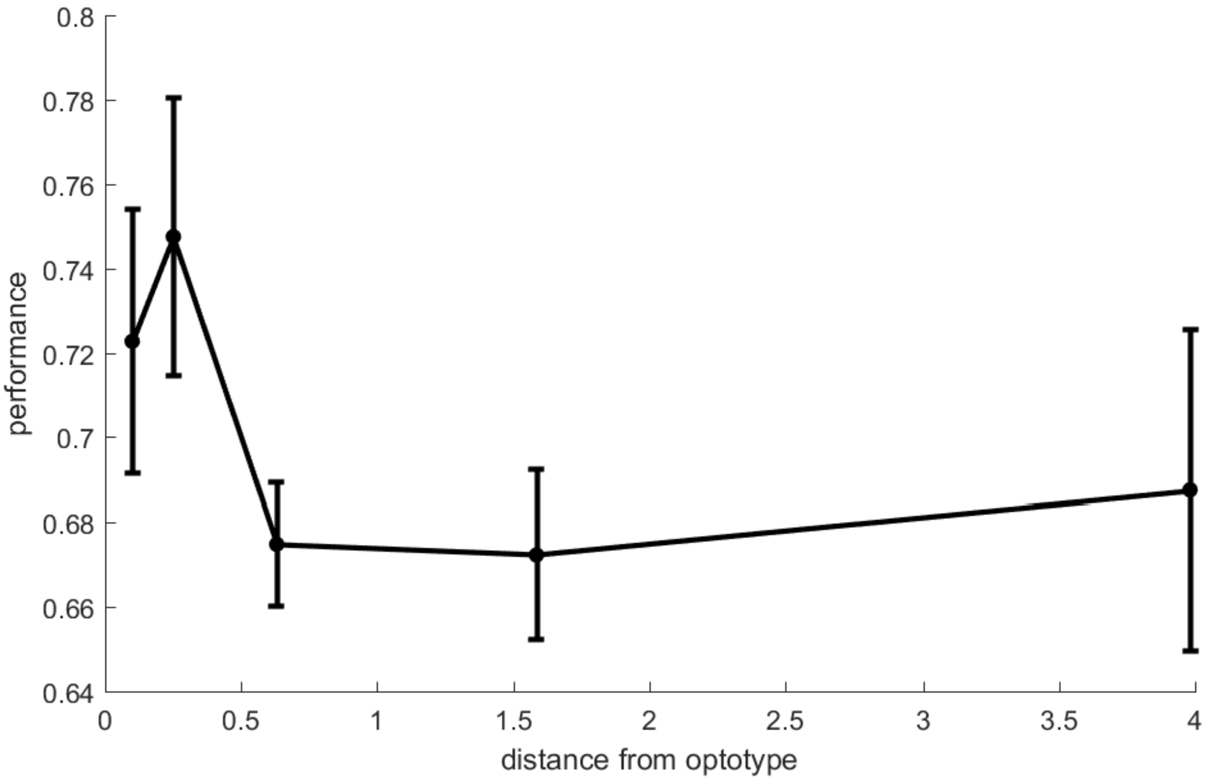


Figure 37: Performance at optotypes binned by minimum distance of gaze (including drifts and saccades). Maybe there is an average trend here but there is no significant main effect from anova. Maybe smaller bins?

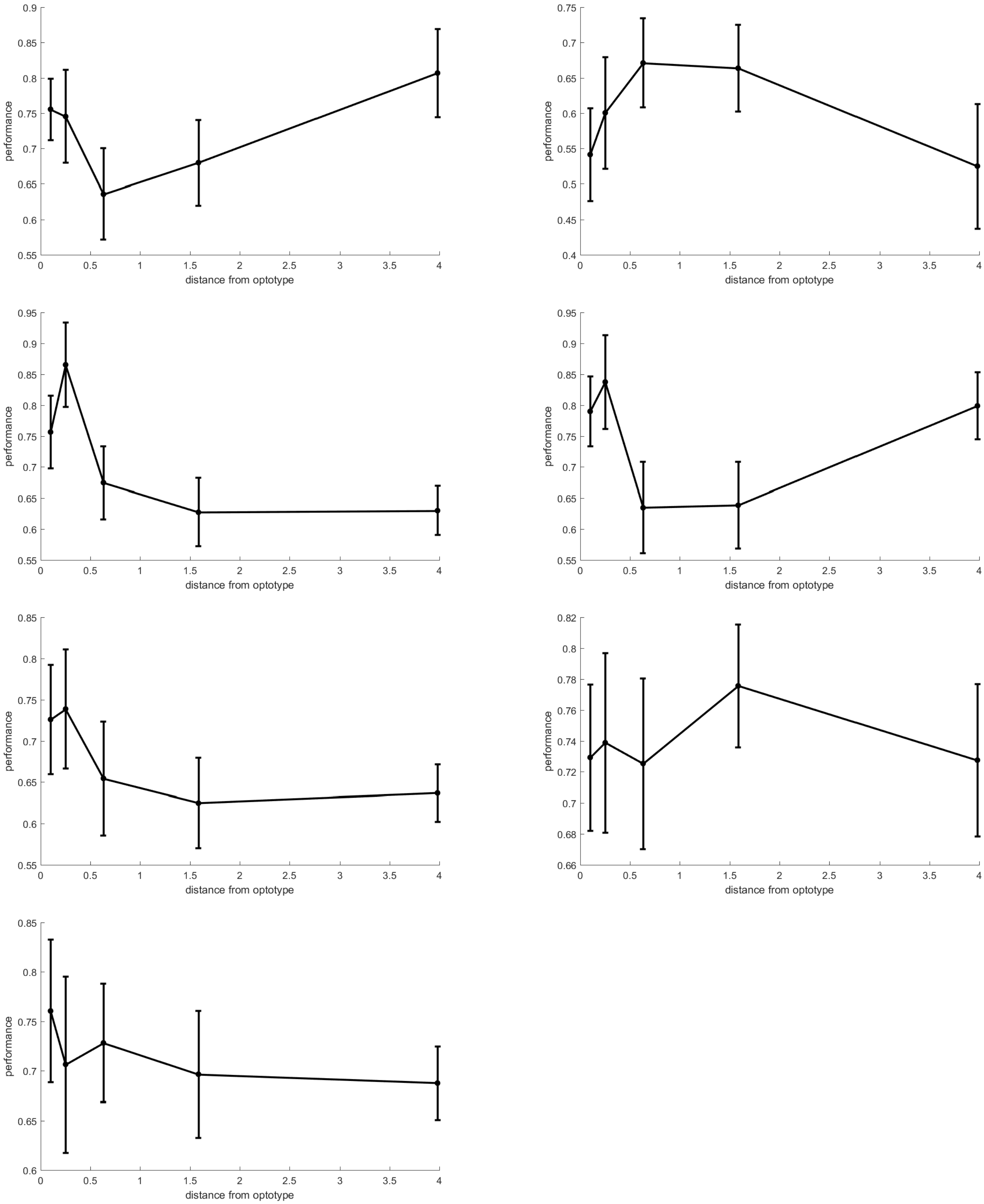


Figure 38: Same as above for each individual subject.

6.6 Trial Durations

Trials durations for the 20/20 line were not significantly different.

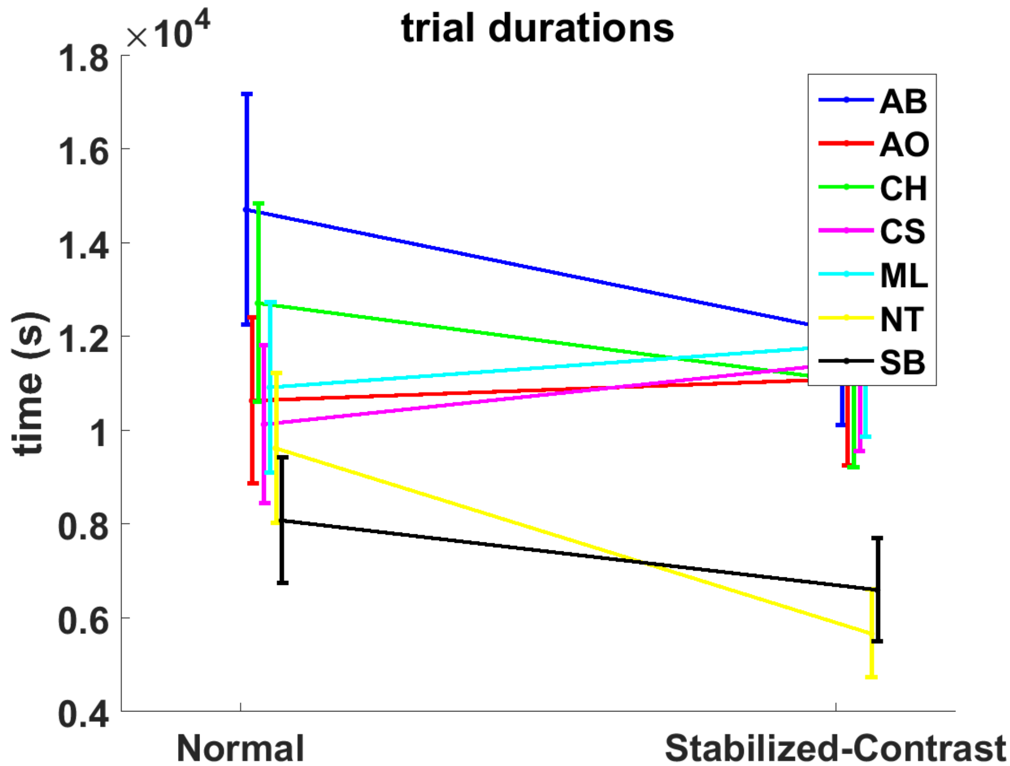


Figure 39: trial durations in normal and stabilized-contrast conditions.